INSTRUMENT MANUAL

PART NUMBER 031426

# SPECTROMETER
# Model 530/530A

BAIRD-ATOMIC

NUCLEAR DIVISION

125 MIDDLESEX TURNPIKE, BEDFORD, MASSACHUSETTS 01730

A precision laboratory instrument designed to count and analyze the repetitive energy of signals produced by various radiation detectors.

For In Vitro Diagnostic Use

Read complete manual before attempting to operate the instrument.

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# SECTION I

# INSTRUMENT INFORMATION

## 1.1 INTRODUCTION

The Model 530 Spectrometer shown in figure 1-1 is a multipurpose flexible, fully automatic solid-state instrument designed to perform critical requirements of radioisotope analysis. It combines three major subassemblies in one instrument for complete identification and analysis of radiation energies. The spectrometer will identify different types of radioactive isotopes in one sample, will also determine the concentration of each isotope, and will display this information numerically on the Model 530 and graphically on the Model 530A. Alternately, the spectrometer will control the analysis of sets of samples, recording the concentrations of selected isotopes. A front panel decade display monitors counting and timing activity constantly.

The Model 530A is identical in all specifications to the Model 530 and has an added feature of analog output which is selectable in four ranges of three decades. They are: 1 to 1,000; 10 to 10,000; 100 to 100,000 and 1,000 to 1,000,000, with accumulate intervals (time constants) of 0.1 to 9999.9 minutes or seconds in the manual mode, and 0.1 to 99.9 minutes or seconds in the automatic mode. The 530A has recorder outputs of 1 milliampere or 100 millivolts, plus an additional output for X-Y plotters. The analog output also includes a buffer storage for essentially no loss of count information at transfer time.

Functionally, the spectrometer consists of the following three subassemblies.

Figure 1-1. Model 530 Spectrometer

### 1.1.1 Scaler-Timer

A high speed, fully automatic six decade scaler and five decade timer, with all presettable digits on count and time plus a background subtract operational mode.

### 1.1.2 Amplifier-Analyzer

A fast, high gain, non-overloading pulse amplifier featuring both a low impedance input (current sensitive) and a high impedance input (voltage sensitive).

### 1.1.3 High Voltage Regulated Power Supply

A dc to dc converter employing a high gain feedback amplifier to control the desired output level, and provide required regulation.

## 1.2 INSTRUMENT DESCRIPTION

A compact steel cabinet houses all spectrometer components. Complete modular construction simplifies troubleshooting and maintenance. The front panel, hinged at the bottom, lowers for convenient access to all printed circuit cards and the SAMPLE CHANGER switch. A stand positioned at the bottom of the cabinet allows inclined operation for control and viewing ease when used on a bench. All circuits are built in modular fashion on 5 x 9 inch glass epoxy printed circuit cards, guided and held in position by two plastic guide strips. The 17 printed circuit cards (18, when DAC feature is included) each plug into a 23-pin connector mounted at the back of the card cage. Extender cards are also available which permit troubleshooting the Spectrometer while it is operating. The system regulated power supply, located behind the card cage, is mounted on a platform that may be pulled out for servicing after removing its mounting hardware. All wiring from the system power supply is channeled through one terminal board.

All mode switches, of the slide variety, are conveniently mounted on a switch panel below the hinged front panel. Connections to other instruments are made through the connector panel located at the rear of the Spectrometer.

## 1.3 DIGITAL-TO-ANALOG CONVERTER DEFINITION

The digital-to-analog converter (DAC), a factory installed accessory, adds the facility of a digital ratemeter to the Model 530 which then becomes known as the Model 530A. Functioning as a digital ratemeter the unit is capable of measuring count accumulation occurring at either regular or random intervals. It presents this information as an analog signal at a set of rear connector terminals for use with a chart recorder. Digital information taken from any three adjacent scaler decades, depending on range switch position, is presented by the DAC card as either a current of 0 to 1 milliamperes, or a voltage over the range of 1 to 100 millivolts. A 99-set output (x) is supplied for x-y recorder operation. DAC circuitry, which is plugged into card position C14, is contained on a printed circuit card consistent with the modular design of the Spectrometer.

## 1.4 SYSTEM USE

The 530 Spectrometer is used as a basic component in several major Baird-Atomic counting systems. These include:

A. Automatic test tube Sample Changer/Counters Systems.

B. Uptake probe stand scintillation systems.

C. Automatic Planchet Changer Systems.

D. Manual Well Counting Systems.

## SECTION II

## USES OF THE INSTRUMENT

The Model 530 Spectrometer (or Model 530A with an analog output for use with strip chart recorders), is designed to meet the majority of radioisotope analysis and counting problems known to laboratory, industrial, and teaching applications. Using various detection methods with the same spectrometer, these systems are capable of performing all types of scintillation as well as gas and gm counting.

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## SECTION III

## INSTALLATION PROCEDURES AND SPECIAL REQUIREMENTS

### 3.1 INSTALLATION

CAUTION

The spectrometer is a very sensitive measuring device, capable of accurately analyzing high speed signals in the fraction of millivolt and fraction of microsecond range. Be careful in unpacking not to drop or damage the unit.

Carefully clean all packing materials, dust, or other foreign matter from the unit. Inspect the unit for damage. After unpacking, if possible, retain and store the transit case and packing materials for possible future reuse. Four rubber feet are provided to allow air to enter the bottom of the cabinet and exit through the top.

CAUTION

If the spectrometer is to be used on a bench, nothing should be placed on top of the instrument that would tend to block air circulation.

CAUTION

When intended for rack mounted applications, take care not to exceed the maximum operating temperature specified (+50°C).

### 3.2 SPECIAL REQUIREMENTS

NOTE

In this type of low level measuring system, the grounding must be carefully (note continued) controlled to eliminate loops and noise pickup.

Within the Spectrometer, the signal wiring from the amplifier input connectors is shielded to the amplifier printed circuit card input pins. However, it is necessary to consider how the phototube and/or preamplifier are connected to the Spectrometer amplifier inputs. If the preamplifier and tube are housed in a metal chassis, the chassis should make electrical connection with the Spectrometer chassis through the shield of the coaxial cable connecting the two units.

NOTE

Superfluous connections between the two chassis can cause a significant increase in noise. When using a preamplifier that does not derive its dc power from the Spectrometer (as do all the preamplifiers in Baird-Atomic probes and well counters) take care to ensure that an unwanted ground loop does not occur through equipment ground in a three-wire power system.

The line cord should be plugged into a 3-wire system to keep the chassis at the same potential as the other system equipment.

### 3.3 REPACKING INSTRUMENT FOR SHIPMENT

If instrument cannot be repaired on the site, the following procedures aid the customer in expediting the return of the spectrometer to the area sales office or factory for repair.

a. Remove transit carton and packing materials from storage.

b. Disconnect all instrument power and interconnecting cables.

c. Clean all dust, dirt, etc. from instrument.

d. Carefully place instrument and accessories into cartons along with packing materials.

e. If trouble has been diagnosed, include a detailed description of the trouble along with packing list of items combined in case.

f. Seal packing case.

g. If not done prior to packing, contact nearest Baird-Atomic sales office* and request shipping information.

*A list of Baird-Atomic sales offices is included at the end of Section X.

## SECTION IV

## PRINCIPLES OF OPERATION

### 4.1 INTRODUCTION

This section contains a detailed discussion of the theory of operation for the three subassemblies that comprise the Model 530 Spectrometer. An overall Spectrometer Logic diagram (figure 4-1) as well as block, logic and timing diagrams are provided to supplement the discussion of each subassembly.

Digital-to-analog converter (DAC) theory, which applies only to those spectrometers equipped with a DAC feature (Model 530A) follows the system power supply discussion.

### 4.2 HIGH VOLTAGE Power Supply (figure 4-2)

Two plug-in printed circuit cards, C22 and C27, comprise the high voltage power supply. The dual range supply is designed to satisfy the most critical requirements of scintillation or proportional counting. Its complete solid-state design increases operational reliability in keeping with the latest trends in transistor circuit design. Basically, the supply is a dc to dc converter using a high gain feedback amplifier to control the desired output level, and provide required regulation. In the 1.5 KV range the output voltage can be selected from 500 to 1490 volts in 100 or 10 volt increments by means of the COARSE ADJUST and FINE ADJUST front panel controls. In the 3 KV range the same controls permit selection of the output voltage from 1500 to 2985 volts in 150 or 15 volt increments.

For ease of maintenance and service, the power supply is mounted on two printed circuit cards which can be removed from the cabinet with minimum effort.

NOTE

A safety interlock (S12) is provided, disabling the supply whenever the front panel is lowered exposing any high voltage areas.

Card C22 contains the circuits associated with the regulator; card C27 houses the transformer, switches and filter circuits. Either card may be independently removed while the power switch is ON provided the interlock is operational, and all high voltage has been removed from the circuit. Referring to figure 4-2, high voltage is generated by alternately shorting each transformer leg to ground through switching transistors. The absolute value of high voltage is determined by the amount of dc applied to the center tap which, in turn, is determined by the high voltage front panel selector settings.

An astable multivibrator generates a 2.5 kc signal and is coupled to a flip flop which functions to produce a symmetrical drive to the transformer switches. In the process, the drive frequency is reduced by a factor of two. A buffer stage, inserted between the flip flop and switches, provides isolation; it also provides a path for leakage current on alternate cycles where the switching transistors are cut off.

To obtain the desired load regulation and stability, a highly efficient regulating circuit is employed to control input voltage to the dc to dc converter. A sampling of the output is compared with a zener reference voltage and the difference amplified, and applied as a correction voltage to the converter transformer. The circuits may be discussed under five major loop elements: sampling, reference, comparison, amplifier, and control.

The sampling element consists of 12 precision resistors mounted on the rear panel RANGE and front panel COARSE and FINE adjust switches. These resistors form an accurate voltage divider with a resistor in series with the reference element. The reference element consists of two zener breakdown diodes in series, which constitute a stable 18 volt source. Two 9 volt units are used in

preference to one 18 volt diode because of the better temperature coefficients obtainable with lower voltage zeners.

The comparison element is a six terminal device containing two electrically identical isolated transistors connected as a difference amplifier. By having the junctions of the two collectors physically close to one another, a difference in parameters with temperature changes can be held to a minimum. The comparison amplifier, as the name implies, compares a portion of the high voltage output with the reference and produces an output proportional to the difference voltage. Since the comparator is referenced to ground, the input appears as a virtual ground.

Any tendency for the output voltage to vary other than in response to a change in sampling resistors will occur as an error signal to the comparator. The error is amplified and applied in correct phase to control the output. When the sampling resistors are changed, for example, if the operator desired to select a different output voltage, the regulator forces the output to a level where the sampling and reference resistors maintain the proper voltage divider ratio.

The comparator output, being insufficient in itself to properly correct for output errors, is coupled to a two stage dc amplifier before being applied to the control element. Total loop gain is sufficient to maintain the output within 0.01 percent for load changes of 5 ma. Because the dc loop encloses all critical parameters, the supply is quite stable over long periods of time.

The control element is a compound-connected series regulator, which reacts to a change in base drive by making the necessary adjustments to transformer voltage. Any change in high voltage output is thereby corrected.

Besides the major dc feedback loop, a minor ac loop is connected from the output of the amplifier to the comparison element. The gain of the loop for 60 and 120 Hertz is high enough to reduce low frequency noise appearing at the output.

Were it not for the high voltage being within a strong dc feedback loop, the output load regulation would be in the order of five percent with an effective output resistance of 15,000 ohms. For stringent load regulator specification the loop must have a minimum gain of 500. To provide operation within specifications over operation life, all components are derated from manufacturer's specification; circuits are designed to operate efficiently with large changes in transistor parameters. With a minimum loop gain of 500, load regulation is held to 0.01 percent of maximum output. Output resistance is then approximately 30 ohms.

To decrease changes in high voltage with ac line variations, a well-regulated low voltage power supply is used as the source of input power. The power transformer provides one percent regulation of rectified output for a ±10 percent change in line voltage. Additional regulation is employed where critical circuitry is required. Since the dc amplifiers are within a strong feedback loop, small changes in operating voltages are not critical.

## 4.3 ANALYZER/AMPLIFIER

### 4.3.1 Amplifier

The amplifier, a nonoverloading type pulse amplifier, is contained on board C18. It features exceptionally high and stable gain and has both a current and voltage input for increased flexibility. As shown in figure 4-3, the amplifier consists of three direct coupled stages connected with an overall dc feedback network to maintain operating point stability. Direct coupling eliminates the need for coupling and bypass capacitors, which could cause severe recovery problems when the amplifier is subjected to a wide dynamic range of signals.

Gain of each stage is controlled by negative feedback loops to stabilize against power supply variations and parameter drifts due to temperature and aging. Amplifier gain is varied by changing the resistors in the feedback loops. To reduce total effective shunting capacity, feedback resistors are located directly on the COARSE GAIN switch.

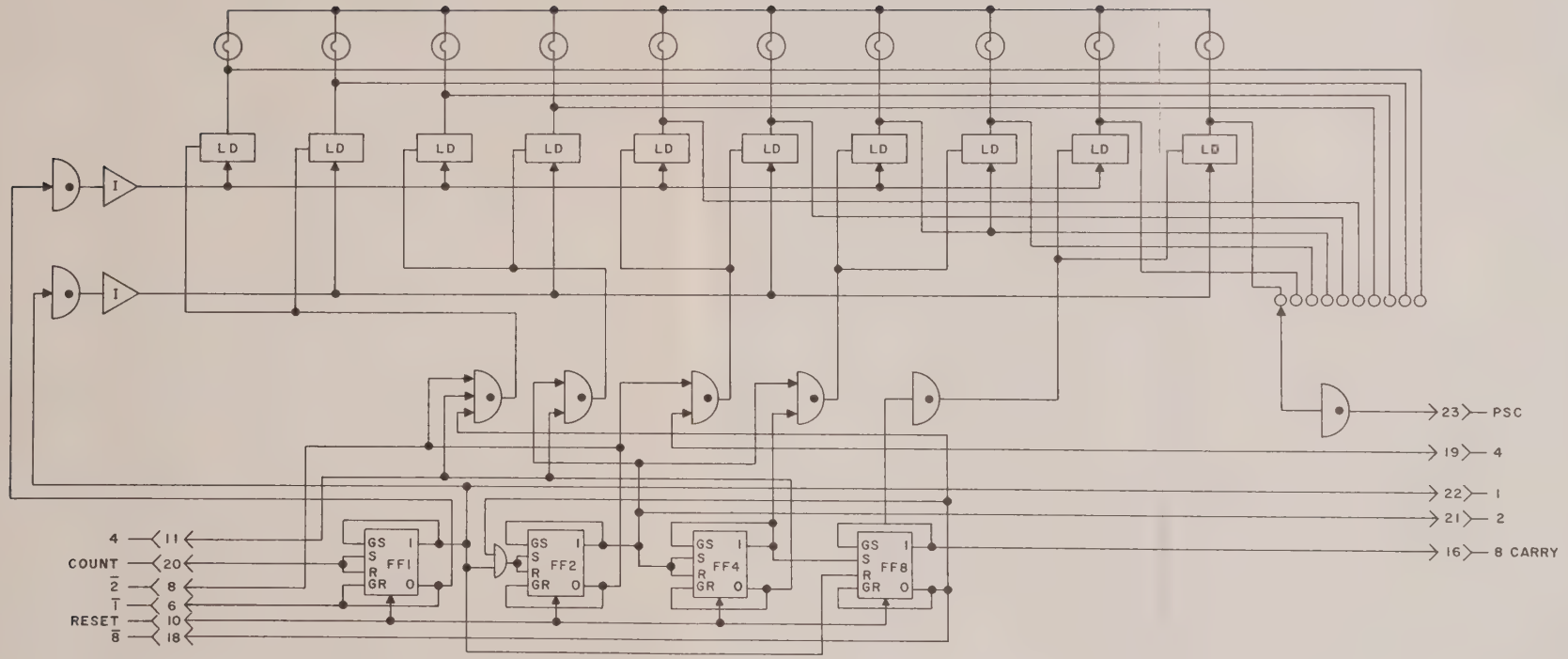


Figure 4-5. 100 kHz and 1 MHz Decade Counter

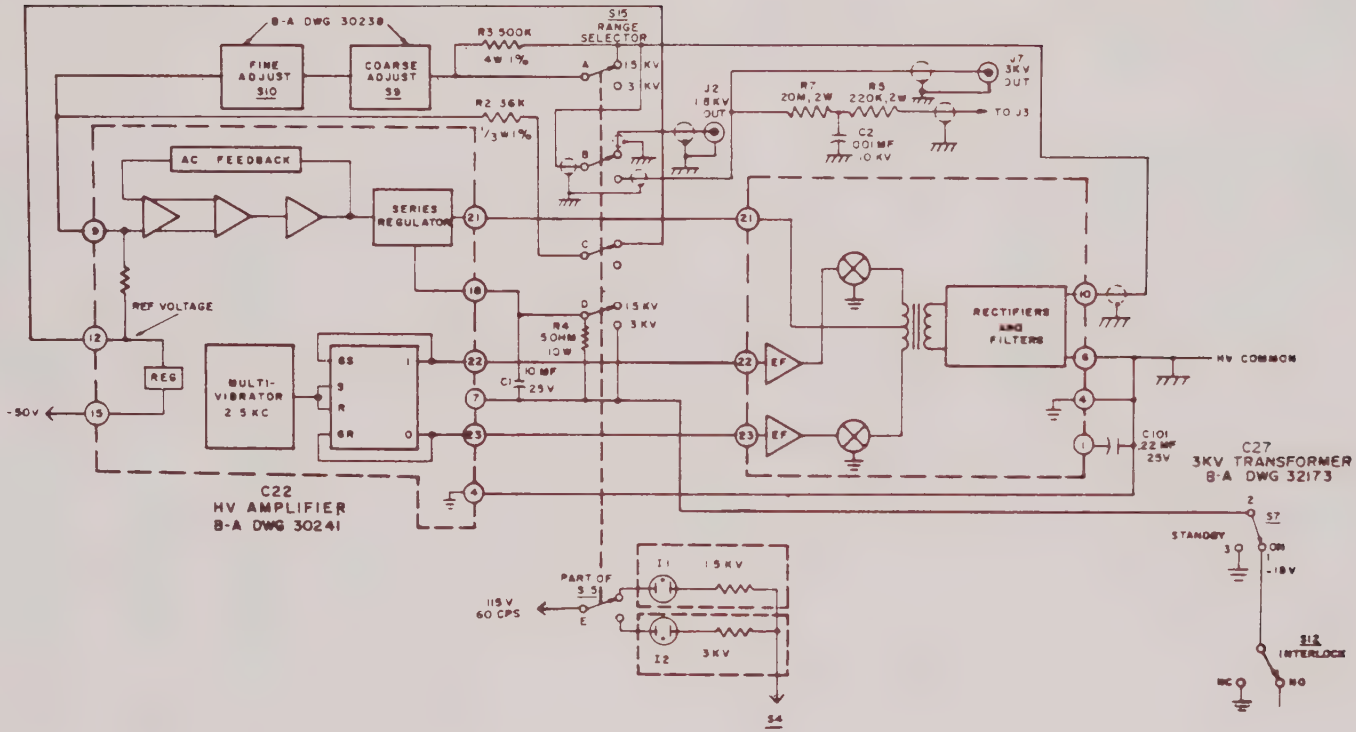


Figure 4-2. High Voltage Power Supply Logic Diagram

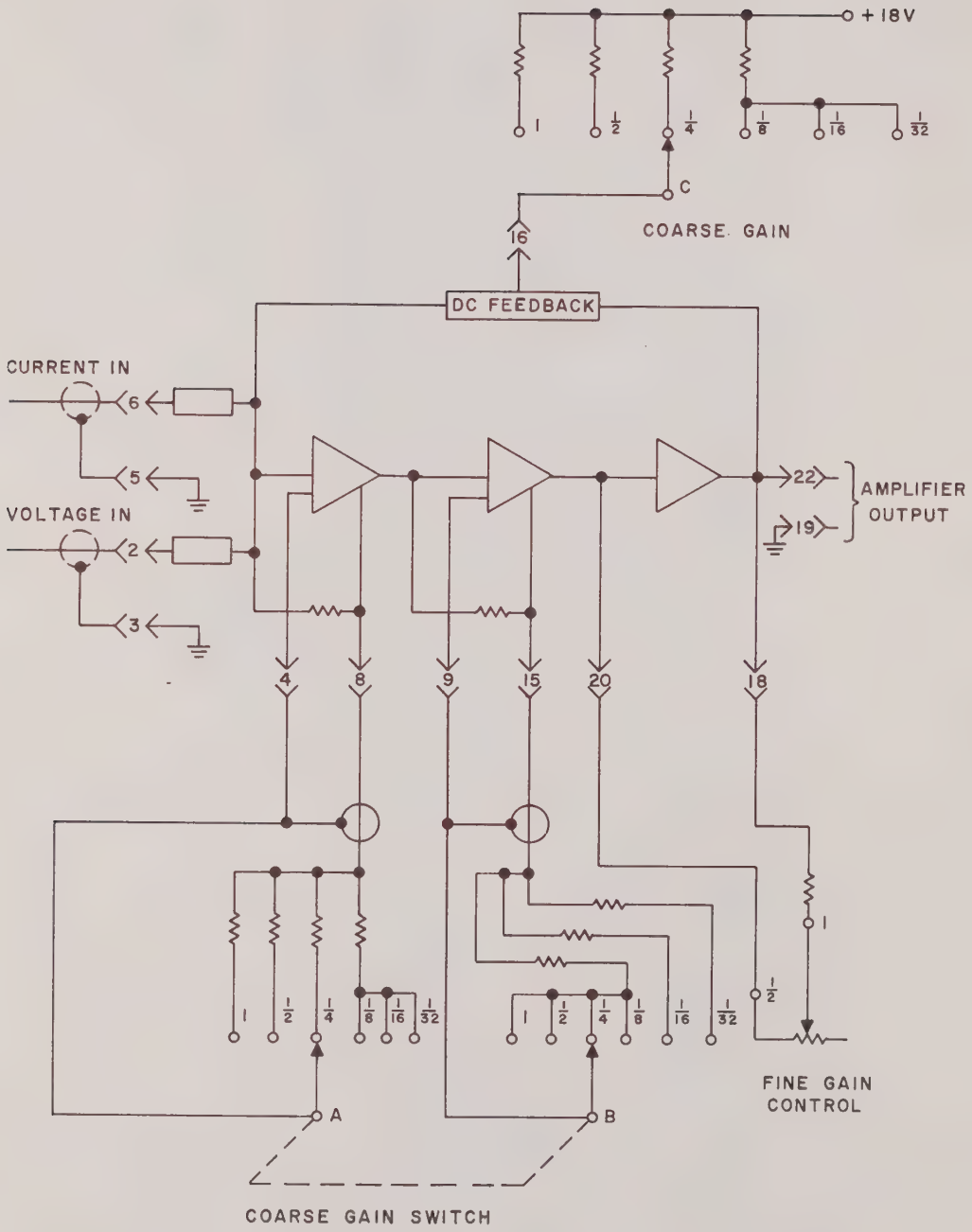


Figure 4-3. Amplifier Logic Diagram

inverters. The second inverter has a negative-going pulse about seven volts in amplitude, and about 0.5 microsecond in width. If the window threshold is not exceeded, the diode gate will be in the enabled state (negative level) and the pulse will also appear at the output, pin 5, after passing through a complementary emitter follower used for capacity buffering.

If the input pulse exeeeds the window threshold as well as the lower level threshold, then a positive pulse also appears at the output of the window discriminator. The pulse passes through an emitter follower and the leading edge of the pulse drives the flip flop to the reset condition which places the diode gate in its inhibit state. The pulse caused by differentiating the trailing edge of the lower level discriminator output will then be prevented from passing through the diode gate. Under this condition no output pulse will appear at pin 5.

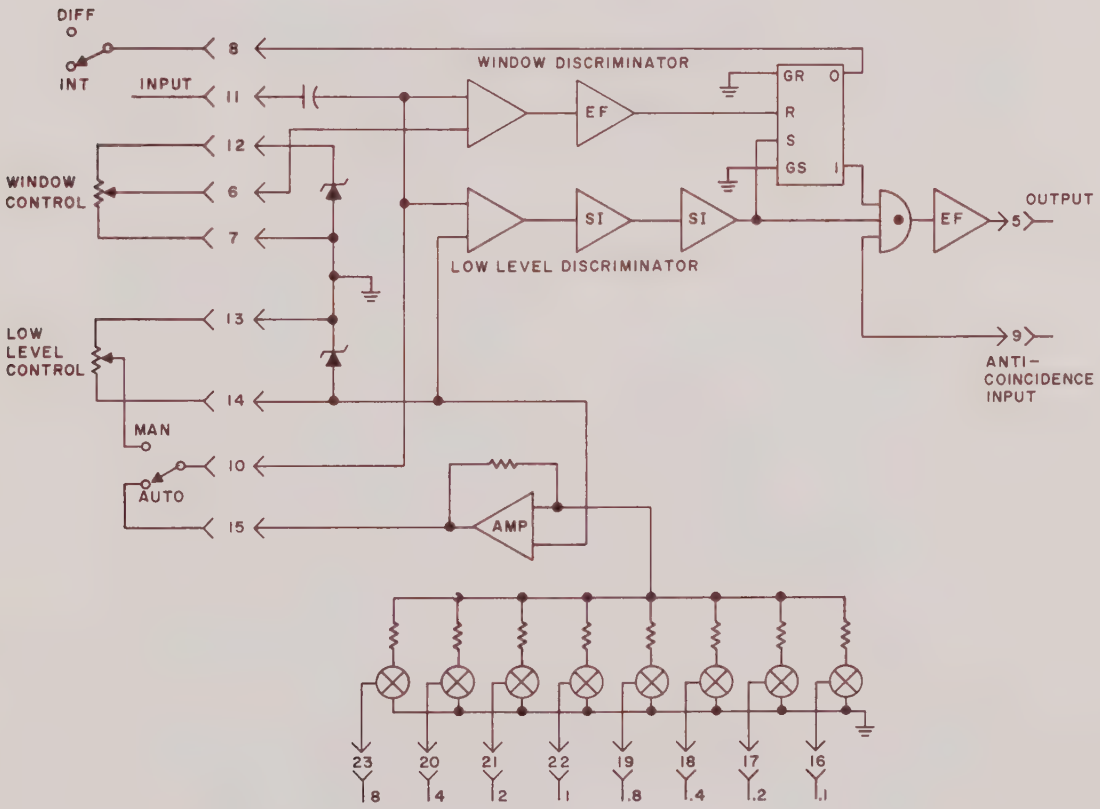


Figure 4-4. Analyzer Logic Diagram

The first stage consists of two doublet stages connected in a stabilized current gain configuration. Each doublet is comprised of a grounded emitter stage driving a grounded base stage in a complementary cascade arrangement. This configuration has proven advantages: high speed operation is enhanced due to the low impedance base to the emitter junction, shunting the high collector impedance, and effectively eliminating the Miller multiplication of base-to-collector capacity. As a further advantage, many such stages may be directly coupled with no "creeping up" of operating points normally encountered in other direct-coupled stages, since each stage can operate with zero volts in and zero volts out.

The second doublet stage is very similar to the first with negative current feedback employed around the two doublets to establish the stage gain. Maximum current gain of the first stage is 32, when the COARSE GAIN switch is in position 1; the maximum gain is 4, when the COARSE GAIN switch in 1/8, 1/16, and 1/32 positions. Frequency stabilization networks control the upper 3 db point of the stage. Stage bandwidth is about 3 MHz.

Since the negative feedback is to the input terminal of the stage, the input impedance of the stage is very low, being equal to the feedback resistor divided by the loop gain of the stage. Input impedance is about 25 ohms. There are two inputs to the amplifier: current input, pin 6, and voltage input, pin 2. The current input is used directly with a phototube with no preamplifier required. Voltage input is used in conjunction with low output impedance preamplifiers.

Input current is amplified in the first stage and passed to the second stage through the grounded base of the second doublet transistor. The second stage is also a current gain stage identical in operation with the first stage. Stage two gain is varied from 32 to 8, and the bandwidth is also about 3 MHz.

The third stage consists of a doublet and a complementary emitter follower section connected as a current-to-voltage transfer stage. The amplified input current, coupled into the third stage, flows through the feedback resistance connected between pins 20 and 18. Feedback resistance consists of a 4.02 k ohm resistor in series with the FINE GAIN control, which is a 5000 ohm wirewound, one-turn potentiometer mounted on the front panel. Frequency stabilized networks set the stage bandwidth at about 2 MHz.

The output of the amplifier, pin 22, is in the form of a voltage pulse. Dynamic output impedance of the complementary emitter follower is low, nominally less than 10 ohms. A major dc feedback network maintains desired operating points within the amplifier. The maximum high frequency amplifier gain, equal to the dc gain if no dc feedback is employed, is 10 volts per microampere.

For example, a one microampere change in base current in the first stage would cause a 10 volt change at the output. The major feedback loop reduces this sensitivity by a factor of 1000. A one microampere dc change in base current in the first stage changes the output by only 3 mv.

Maximum amplifier gain of the amplifier is 1000, referring to the voltage input, and 10 volts per microampere, referring to the current input. Gain may be reduced by factors of two with the COARSE GAIN control set to a minimum of 1/32 of the maximum. The FINE GAIN control allows continuous adjustment over a 2 to 1 range. This permits the gain of the amplifier to be set anywhere from 16 to 1000. Amplifier linear range output is about 15 volts, or approximately fifty percent over analyzer input range.

### 4.3.2 Analyzer

Figure 4-4 graphically illustrates the single channel pulse height analyzer contained on card C15. The analyzer consists of a lower level discriminator, a window discriminator, pulse shaping circuits, coincidence gating, and a digital-to-analog converter for automatically advancing the baseline.

The input pulse is fed into both discriminators which have zero gain until the threshold is exceeded, after which the gain is quite large. If the pulse exceeds the lower level threshold, a positive pulse appears at the discriminator output. The negative-going trailing edge of the pulse is differentiated and shaped by two shaping

lower level discriminator output will then be prevented from passing through the diode gate. Under this condition no output pulse will appear at pin 5.

The collector of the flip flop transistor is brought out through pin 8 to the INT-DIFF front panel switch where it is grounded in INT operation. Grounding the flip flop keeps it in the set condition. Every pulse which then exceeds the LOWER LEVEL setting appears as an output pulse whether it also exceeds the WINDOW setting or not.

The use of the flip flop as the gating element for the window discriminator has several advantages. First, it provides a custom-tailored inhibiting signal if the upper level as well as lower level discriminator is exceeded. The inhibit signal at the output gate is set up during the leading edge of the pulse. The inhibit level is not removed until after the pulse width is being inhibited expires, for the pulse trailing edge is used to return the flip flop to its enabled state. The lower level pulse may occur any time during the decay time of the input signal, determined by the relative position of the lower level discriminator to the height of the pulse. The inhibit signal will vary in width depending upon how much the input pulse exceeds the threshold. Resolving time is fast while guaranteeing that erroneous pulses will not be passed because they are wider than anticipated. There is no need, for adjusting a "resolving time" control which changes a fixed inhibiting level width in finite increments. Last, there is no need for costly and bulky shaping techniques such as delay line differentiation required with some analyzers to give a precise pulse width, so the circuits will function during overload. With the Baird-Atomic analyzer, wide pulses that occur during amplifier overload are handled like linear pulses.

The lower level discrimination level may be set manually with a 10-turn precision (LOWER LEVEL) potentiometer, or automatically by the Digital-to-Analog Converter. Window discrimination is always established by the WINDOW 10-turn precision potentiometer.

The lower level discrimination is performed in a differential discriminator, the base of which is referenced at about -0.7 volt and brought out to the MAN-AUTO switch. The front panel LOWER LEVEL turning dial of the 10-potentiometer is calibrated in percent of full scale; extreme precision in setting may be accomplished since the smallest graduations on the dial are in 0.1 percent increments. The LOWER LEVEL setting establishes the reverse bias on the base-to-emitter junction. A factory adjustment nulls out an initial base-to-emitter junction drop so that zero bias exists when the potentiometer is set at zero. With no pulse present at the analyzer input, pin 11, part of the lower level discriminator is fully conducting, the other part is not conducting. When an input pulse exceeds the reverse bias set by the LOWER LEVEL control, the non-conducting part starts to conduct, taking a portion of the 3.5 ma available from the current source away from the part conducting, the collector of which rises toward +18 volts. The position rise is coupled back to the base of the part starting to conduct, to give a small amount of positive feedback which increases the discriminator gain and speed. Average gain from the input to the collector is about 500 as the discriminator passes from nonconduction to full conduction.

The window discriminator is similar in operation to the lower level discriminator. Since the base of the lower level discriminator is connected to the LOWER LEVEL control, through pin 10, it can vary between zero volts and -9 volts. The WINDOW setting, which can be varied between zero and +9 volts, always rides on top of the LOWER LEVEL control and is never independent of it. The setting of the WINDOW control is from zero to 100 percent of full scale. However, the linear range is determined by the amplifier that precedes it. Since the full scale range of the analyzer is 9 volts, and that of the amplifier 15 volts, maximum WINDOW setting for linear operation at any baseline setting, including at 100 percent is 50 percent. When operating with less than 100 percent baseline, the difference may be applied to the WINDOW setting. For example, if the LOWER LEVEL is set for 50 percent or less, the WINDOW setting may go up to 100 percent.

When the analyzer mode switch is moved from MAN to AUTO, the front panel LOWER LEVEL control is disconnected from the discriminator and the digital-to-analog converter is switched in. DAC amplifier low impedance is brought out on pin 15 and switched into pin 10 as the lower level bias voltage for both discriminators. Control signals, generated from the outputs of two binary-coded

decimal decade counters operating between the logic levels of zero volts for binary zero to -6 volt for binary one, are brought in on pins 16 to 23 for the eight switches. The switches control binary-coded decimal-weighted resistors which determine the amount of current flowing into the DAC amplifier input summing point. The amplifier output voltage is proportional to the input summing point current.

Counters used for controlling the DAC switches in AUTO are the two most significant digits of the five-decade timer during the MAN operation. The counters (see figure 4-1), advance by one count each time the scaler-timer is started, thereby advancing the baseline by one channel or one percent, each time. The baseline stays at that setting until the scaler-timer is stopped and then started again. The automatic baseline feature automatically sweeps the lower level discriminator through its full range in one percent increments, permitting a complete spectrum to be gathered and automatically printed.

## 4.4 SCALER/TIMER

The scaler-timer consists of a six-decade, 1-microsecond resolving time scaler, and a five-decade timer. Each digit of every decade is presettable by means of front panel mounted thumbwheel switches. The scaler-timer contains a background subtract feature as well as an automatic operation mode. The four line outputs of all eleven decades are designed to operate directly into a parallel printer such as the Baird-Atomic Model 620 Printer (see Section 1.0) which prints out at three lines per second maximum.

Physically, the scaler-timer is constructed on 13 printed circuit cards. The scaler control card, C1 (figure 4-1), contains all control logic for starting, resetting, and stopping the scaler-timer. This card also contains the background subtract and printer command circuits. The six decades of the scaler are located in card positions C2 to C7. Each decade card is complete within itself, containing the 10-lamp incandescent readout display and 10-position thumbwheel switch, and a four-stage flip flop counter. The least significant decade of the scaler, C7, is a 1 MHz decade card. The other decades, C2 to C6, are 100 kHz decade cards.

The timer countdown card, C8, contains the flip flop counters which divide down the 60 Hz power signal to 0.1 second and 0.1 minute signals, either of which is selectable as the time base of the timer. Card positions C9 to C13 contain 100 KHz decade cards for the five decades of the timer. These five cards are identical and interchangeable with the five 100 kHz decade cards used in the scaler. When the automatic baseline feature of the analyzer is employed, the decades in C9 and C10 are used to count channel numbers rather than indicating the two most significant digits of the timer.

### 4.4.1 100 kHz Decade Counter

The 100 kHz decade counter shown in figure 4-5 contains a four-stage binary-coded decimal counter, a BCD-to-decimal converter, 10 lamp drivers and lamps, and a 10-position thumb-wheel switch.

The counter consists of four flip flops connected to give a 1-2-4-8 BCD code output. A BCD counter differs from a straight four-stage binary counter in that the counter recycles after 10 input pulses rather than 16 pulses. The counter starts in a reset condition of zero. As each input pulse comes in, the count advances from zero to nine in normal binary fashion. However, the tenth input pulse restores the count to zero rather than to ten. Since negative logic is employed, a flip flop is in the ONE or set state when the ONE output is negative; it is in the ZERO or reset state when the ONE output is at ground. A flip flop changes state when its input changes from a ONE to a ZERO state. The negative level is normally -6 volts plus or minus 1; the zero outputs of the decade are -10 volts plus or minus 2 volts to be compatible with the printer that it drives.

As figure 4-6 shows, the relative timing of the four stages is identical to that of the first ten states of a four-stage binary counter. The BCD counter is implemented in the following manner:

FF1 is complemented by the input signal coming in on pin 20 (figure 4-5). FF1 then drives the complement input of FF2 through the AND gate. FF8 remains in the enabled condition until the eighth

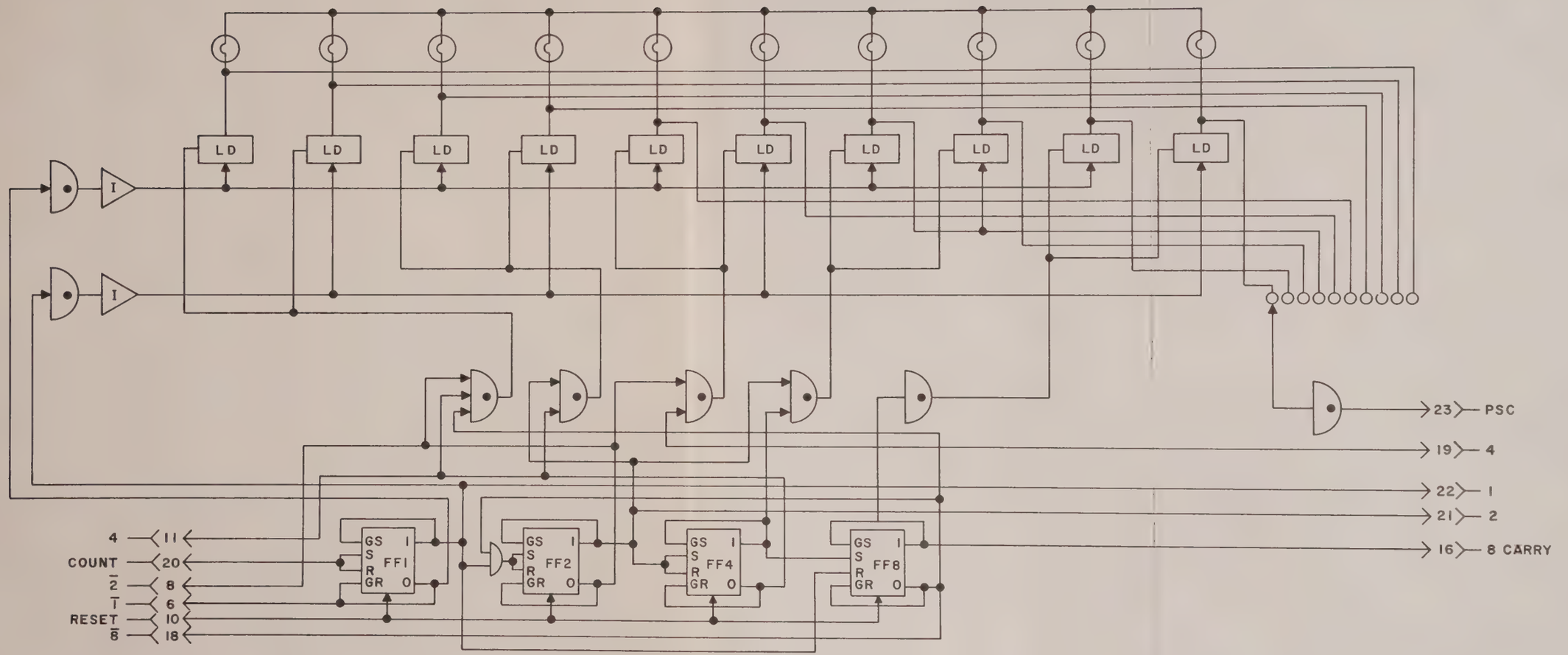


Figure 4-5. 100 kHz and 1 MHz Decade Counter

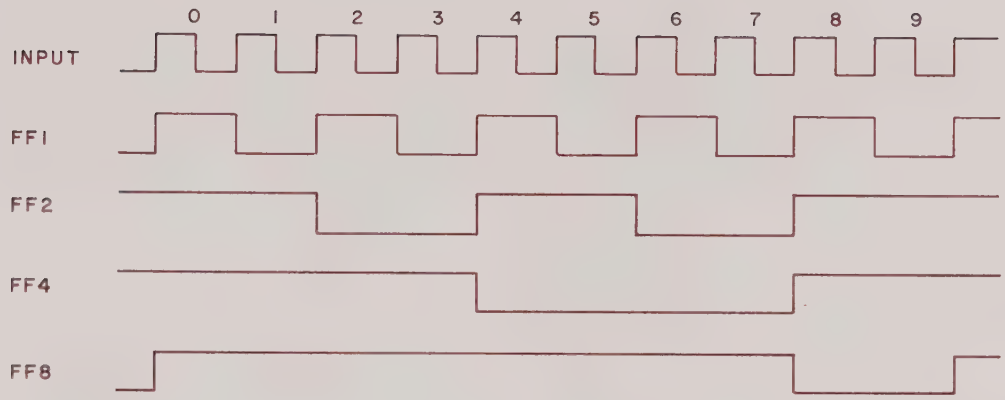


Figure 4-6. BCD Counter Timing Diagram

input pulse is received. FF2 changes states when the second, fourth, sixth and eighth pulses arrive. FF8 is in the inhibit condition from the time the eighth pulse is counted until the tenth pulse. Because FF1 is prevented from coupling when the tenth pulse arrives, FF2 is inhibited from changing states. After the tenth pulse, FF2 and FF1 are in the reset condition. FF2 drives directly into the complement input of FF4. Since FF2 is reset from the ONE state to the ZERO state with the fourth and eighth pulses, FF4 is set with the fourth pulse and reset with the eighth pulse. FF4 drives the set input of FF8. When FF4 goes positive on the eighth pulse, FF8 is driven to the set state. FF8 is returned to the reset state by FF1 when the tenth pulse arrives. Therefore, after the tenth pulse, all four flip flops are in the reset condition, ready to start the count of ten again. The output of FF8 is taken out through pin 16 to connect to the input of the next decade. The outputs of the ZERO sides of the flip flops (used since positive logic is employed) are taken out on pins 6, 8, 11 and 18 to drive a parallel printer.

The direct reset input is brought in on pin 10. When a positive pulse appears at pin 10, all flip flops are forced in a reset condition.

Incandescent lamps indicate the state of the counter at any instant. Lamp DS101 lights up numeral 0, DS102 lights up numeral 1, and so forth. Emitters of the even numeral drives are connected together; emitters of the odd numeral drives are also connected together, but separately from the even numerals.

Multiple use is made of the decoding done for the lamps. The output of each driver connects to one of ten positions of the thumbwheel switch mounted on the card. The switches are used for presetting a count on the scaler or timer. When the count is reached corresponding to the setting of the switch, the cathode of the decade diode is driven positive. The anode of the diode is brought out to pin 23 where it is wired to the anodes of similar diodes in other decades, forming a positive AND gate. When the count is reached in each decade corresponding to the switch setting in that decade, a positive going pulse occurs at the output of the gate, which is then used for stopping the counting operation.

4.4.2 1 mHz Decade Counter

A higher speed flip flop is used in the

1 mHz decade counter. See figure 4-5 for the detailed logic diagram.

4.4.3 Timer Countdown

A timer countdown board shown in figure 4-7 generates a clock signal used as a time base for the scaler-timer. Line frequency is used as the input signal source. The 60 Hz sine wave is shaped in a Schmitt trigger and then frequency divided by six (figure 4-8) to generate a clock signal at pin 5 which occurs at a 10 Hz rate or a 0.1 second period. The 10 Hz signal is then divided by ten to give a 1 second clock at pin 16. The signal is further divided down by a factor of six presenting a 0.1 minute clock at pin 15.

Either the 0.1 second or the 0.1 minute signal is selected by the front panel 0.1 SEC - 0.1 MIN two-position switch. The selected clock signal is gated with the operate (OP) signal before being applied to the input of the least significant digit of the timer. If the equipment is connected to a 50 Hz power source, the first counter can easily be changed to a divide-by-five (figure 4-9) rather than six, by moving one jumper on the card.

The nine volt peak-to-peak 60 Hz sine wave is connected through pin 12 to the Schmitt trigger, which squares up the signal and establishes the proper signal levels. The divide-by-six consists of a three-stage flip flop counter accomplished by resetting to the complement of the total count capacity desired, rather than resetting to zero.

The counter starts off with a ZERO FF1 and FF4 and a ONE in FF2. The first flip flop, FF1, complements with the output of the Schmitt trigger. The second flip flop, FF2 complements from FF1. FF2 resets with the second pulse and sets with the fourth, but is inhibited from resetting when the sixth pulse comes in. Since the third flip flop, FF4, is set by FF2, it goes to the set state with the second input pulse, and stays set until FF4 is reset with the sixth input pulse. The counter then starts off with a count of two, counts to seven, and then repeats.

When a 50 Hz source is used, this causes the counter to reset to a count of three rather than two. In the divide-by-five counter, FF1 is inhibited from resetting after the fifth pulse, or when the counter is in state 7. If FF1 does not reset, FF2 remains set. FF4 is reset with the first pulse causing the counter to go from state 7 to 3.

The first counter output contains one pulse every 0.1 second. The second counter is a four-stage binary-coded decimal which divides by ten thus producing one pulse out for every ten input pulses. BCD counter output, pin 16, consists of a pulse every one second, when in turn drives another similarly operated divide-by-six counter.

4.4.4 Scaler Control

The Scaler Control card, figure 4-10, generates printer command signals, contains background subtract circuits, and all circuits for starting, stopping, and resetting the scaler-timer.

The output from the analyzer (figure 4-1) feeds into the 5-volt input, pin 5, passes through some gating and comes out at pin 11 to drive the first scaler decade. The gating of the analyzer signal is under control of the OP flip flop, which also controls the application of the clock signal to the timer decades.

When the mode switch is set to MAN or AUTO, either pin 15 or pin 12 is grounded, causing the inverter output to go negative. When the mode switch is in the TEST position, the converse is true, the clock signal is applied to the scaler as a test input.

When in the MAN mode of operation, the start function is accomplished by pressing the START pushbutton. When the Spectrometer is in the AUTO mode, starting is automatically accomplished via a signal from the scaler control card.

The start operation is always synchronized to the timer clock and always provides a reset pulse to the scaler and timer first. When the START button is pressed, a pulse at pin 7 triggers the delay flop which gives out a positive going 10 microsecond pulse from its ZERO side, and a negative going pulse from its ONE side. The leading edge of the positive pulse is differentiated and passes through an emitter follower to pin 10 to reset the scaler.

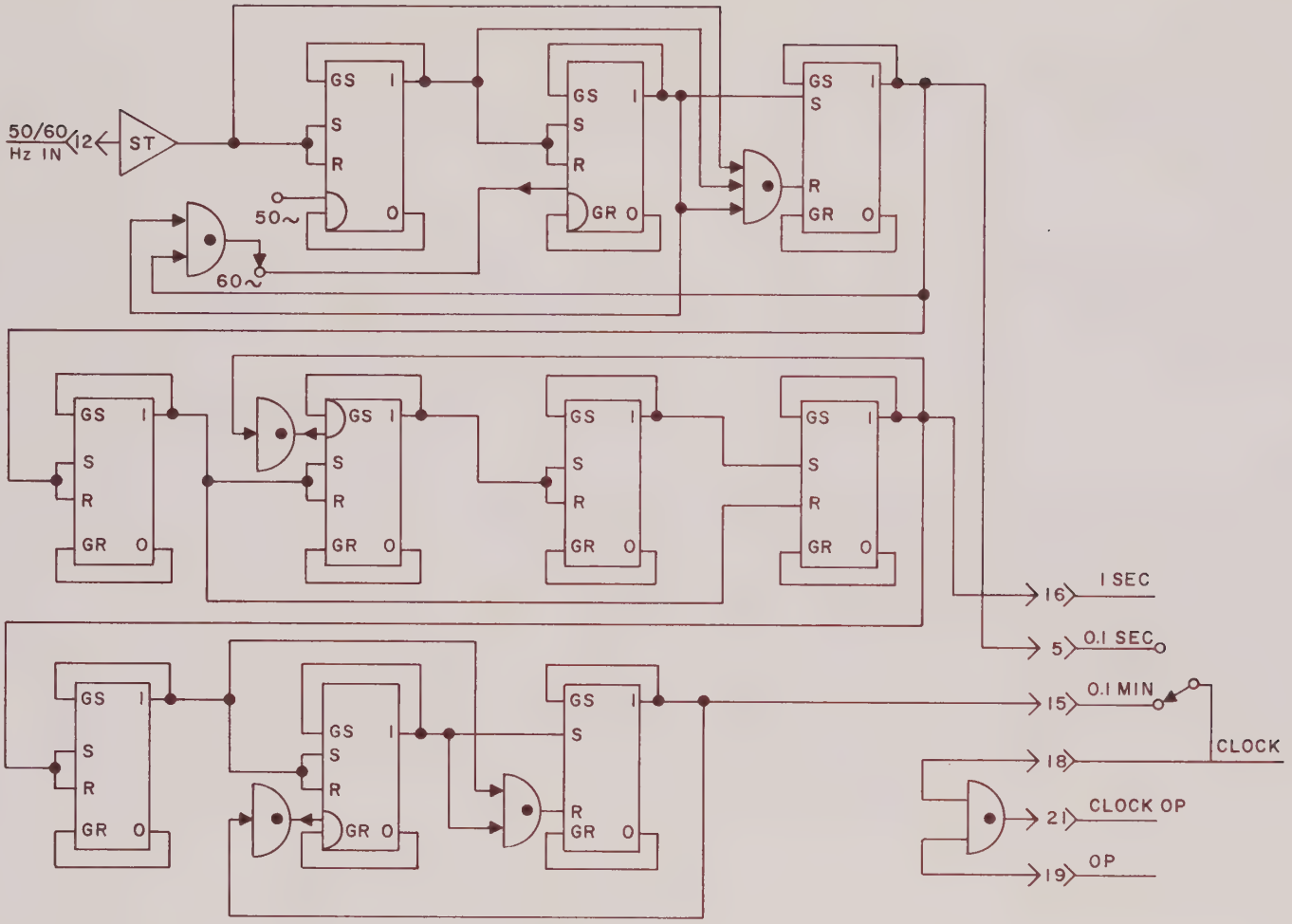


Figure 4-7. Timing Countdown Logic Diagram

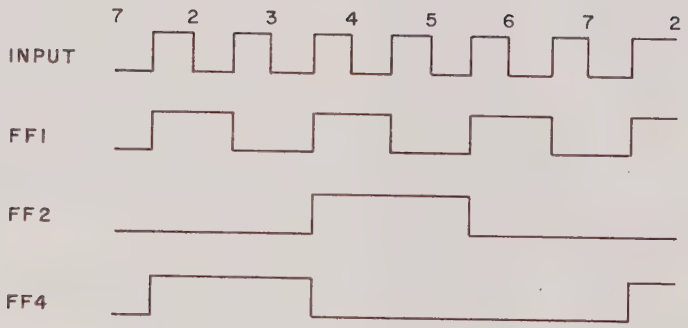


Figure 4-8. Divide-by-Six Timing Diagram

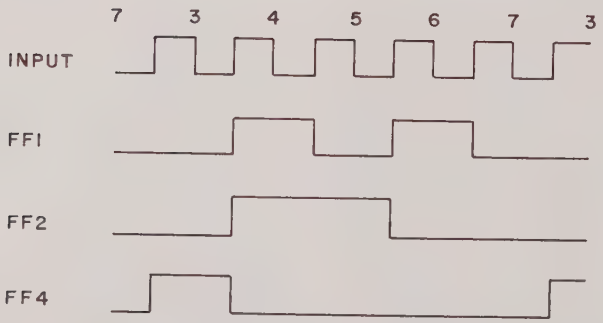


Figure 4-9. Divide-by-Five Timing Diagram

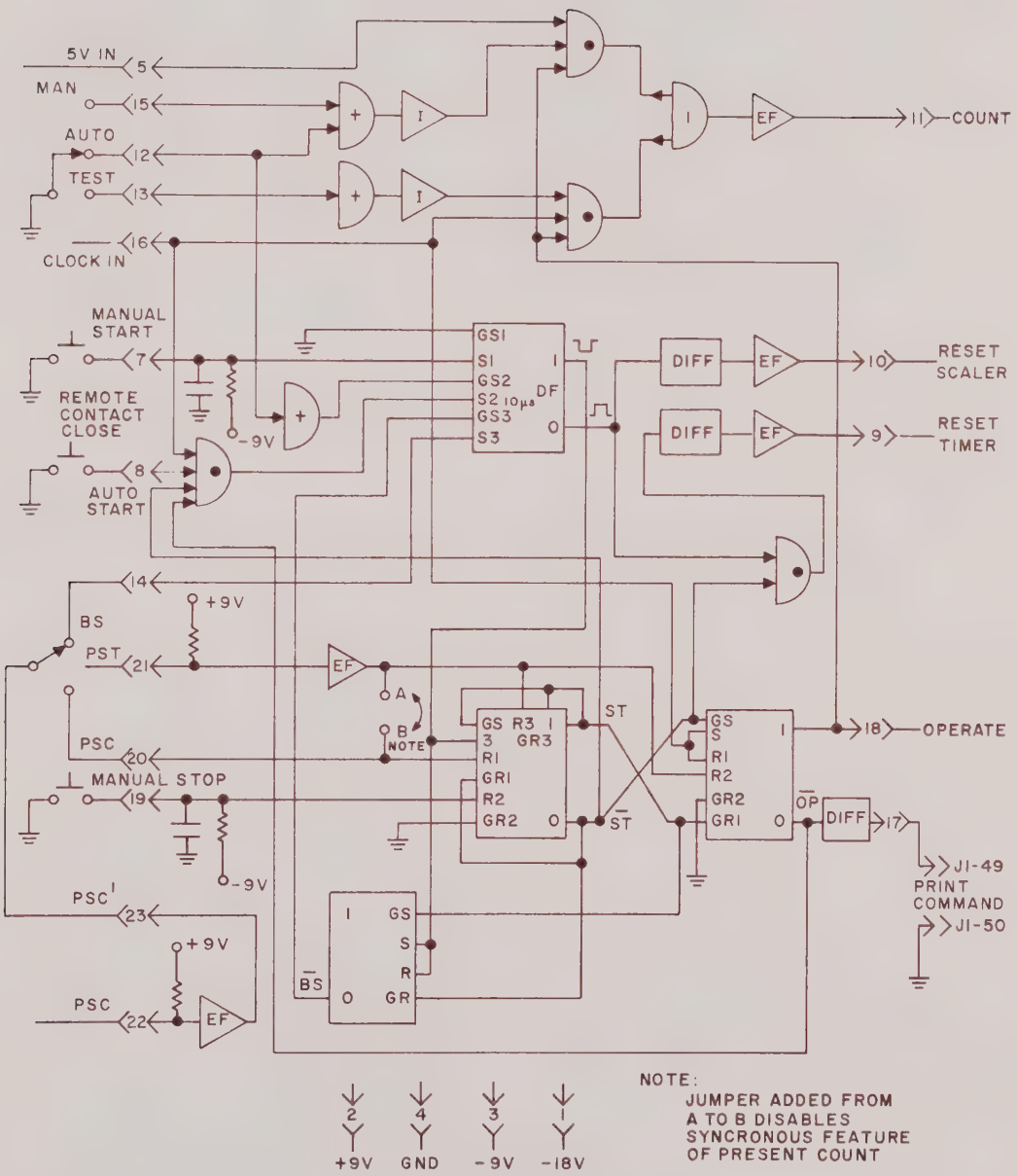


Figure 4-10. Scaler Control Logic Diagram

The positive pulse also passes through a gate, which is enabled when the scaler is in the STOP position. This pulse passes on through a differentiator and emitter follower to pin 9 to reset the timer.

The trailing edge of the 10 microsecond negative pulse from the delay flop drives the set input of the start (ST) flip flop, used for synchronizing the start of scaler operation with that of the timer. ST and $\overline{ST}$ signals condition the gate set, and gate reset inputs of the OP flip flop, allowing the next clock that occurs to set it. The OP signal goes negative, conditions the count gates, and allows either the analyzer signal or the test signal to drive and count input of the scaler. The OP signal also goes to the timer countdown card where it enables the clock to drive the timer.

When the mode switch is in AUTO, GS2, another gate set input of the delay flop is enabled, allowing the S2 input to trigger it. The S2 input is driven by a gate which is connected to the clock signal (pin 16). The gate is enabled when the ST and OP flip flop are in the stop state. Another input to the gate at pin 8 allows an external device to control the starting function. When the printer is employed an "inhibit start" signal, consisting of contact closure to ground, prevents the start function, while the printer is getting set to print. Once the printer does not require the data inputs any longer, the contacts open, enabling the gate which allows the next clock signal to pass and trigger the delay flop. Then the signal at pin 8 behaves as an inhibiting rather than a triggering function.

In any mode of operation the counting cycle may be stopped in one of three ways: manually, preset time (PST), or preset count (PSC). Each of the methods is an overriding type, stopping the count if it occurs before any of the others. When the STOP pushbutton is pressed, the ST flip flop resets, conditioning the OP flip flop to reset on the next clock pulse. Once the OP flip flop resets, the counting stops.

For PST stop, when the timer reaches the number preset on its thumbwheel switches, a positive pulse appears at pin 21, passes through an emitter follower, and resets both the ST and OP flip flops. The scaler control card is normally provided with synchronous PSC. When the scaler count reaches the number preset on the scaler thumbwheel switches, a positive pulse appears at pin 22 and passes through the emitter follower to pin 23. It then goes through the preset count-background subtract (PSC-BS) switch.

In the PSC position, the signal reenters the scaler control card through pin 20 and resets the ST flip flop. The stop is synchronized since the OP flip flop does not reset until the next clock pulse. Meanwhile until the clock arrives, the scaler is allowed to accumulate counts over and above the number preset on the scaler. When the next clock arrives, the OP flip flop resets, stopping the count. The total count displayed in the scaler, then, is the exact number of counts which occurred in the timer interval displayed in the timer.

Some users prefer to stop and count nonsynchronously on the exact count preset, so provision has been made to disable the synchronous feature. By adding a jumper, as shown in figure 4-10, between points A and B in the scaler control card, the scaler will be in the nonsynchronous preset count state.

The OP signal is differentiated and brought out to pin 17 as the Print Command Signal. Whenever the scaler is stopped the printer receives the Print Command Signal, a 15 volt negative going pulse with a 40 millisecond decay time, to initiate the print cycle.

When the PSC-BS switch is in the BS position, the PSC signal, generated when the scaler reaches the number set in the scaler thumbwheel switches, is directed via pin 14 to the delay flop which triggers resetting the scaler. However, no reset timer pulse occurs since the delay flop signal is gated with the ST signal to generate a reset timer pulse. Since the ST is in the set state when the scaler is running $\overline{ST}$ will be at ground, inhibiting the gate and blocking the reset timer pulse. Only the scaler then, and not the timer, resets when the present number is reached and the count continues.

The delay flop signal also drives the flip flop marked $\overline{BS}$, used to control the application of the preset signal to the delay flop. When the scaler is stopped, the ST flip flop is in such a

state as to condition the gate set of the $\overline{BS}$ flip flop. $\overline{BS}$ goes to ground, enabling the gate set input GS3 of the delay flop. When the scaler reaches the preset background count, it pulses the S3 input of the delay flop, triggering it.

This particular pulse also drives the $\overline{BS}$ signal to -6 volts, and thereby inhibits the GS3 input to the delay flop. The next time the scaler reaches the background count, it is prevented from triggering the delay flop. The count then continues and stops only on commands derived from setting the PST or MAN controls.

## 4.5 SYSTEM POWER SUPPLY

The system power supply as shown in figure 4-1 is designed to provide reliable Spectrometer operation over a wide range of line conditions. Using a constant voltage ferroresonant transformer, the power supply offers fast line regulation, short circuit protection, automatic current limiting and increased circuit reliability. This type of system supply need only be followed by additional regulations where most critical circuit operation is required.

The basic supply consists of a full wave capacitor input circuit. The transformer, a constant voltage device, provides for one percent regulation of the raw supply over all normal line variations. For those circuits requiring a higher degree of regulation and isolation, adddi tional regulators have been incorporated to provide -15, -9, +9, and +18 volts. These series regulators are emitter followers whose output voltage is maintained substantially constant. A divider provides a nine volt signal referenced from the line used as the timing pulse for the scaler control. A separate winding provides an additional regulated voltage rectified and filtered to produce a -50 volt supply.

## 4.6 DIGITAL-TO-ANALOG CONVERTER (DAC-EQUIPPED MODEL 530A)

The DAC printed circuit card, which plugs into card position C14, is a combination triple decade buffer storage register and digital-to-analog converter. The system (figure 4-11) is designed to accept the 1-2-4-8- binary coded decimal (BCD) logic from any three adjacent scaler decades on command from the scaler control card at the end of a preset counting run.

Upon reaching a preset time, the scaler will stop counting and charge up the DAC input capacitors. On the next timing mark, because the spectrometer remote start line is not inhibited, the scaler-timer will receive a start command which triggers a delay flop. The scaler-timer and the DAC card are reset at the start of the delay flop period, and the DAC card receives a read command at the end of the delay flop period.

Since the time constant of the DAC input network is much longer than the delay flop period, only a very small portion of the charge on the capacitor is lost and each of the register flip flops which is properly biased by an active decade line will trigger. The DAC card is actually a buffer register consisting of three binary coded decades that serve as memory elements for the three most significant decade positions being counted. These must be determined prior to recording serious data by making a few trial runs at which time the preset time and recorder speed are selected.

The analog signal is developed across the output resistors by a set of properly weighted precision resistors serving as the load resistors in each of the normally OFF sides of the register decade flip flops. The scheme used to obtain the correct analog output is shown in figure 4-12, where the ON flip flops are shown shaded. The ON flip flops are binary flip flop 2 in the units decade, binary flip flop 8 in the tens decade, and binary flip flops in 1 and 4 in the 100s decade. Since binary flip flops 1 and 4 are in the 100s column. they must have a combined weight equal to 50 percent of the total current for full scale recorder reading in $R_L$. Binary 8 in the tens column adds 8 percent and binary 2 in the units decade brings the total output current in $R_L$ to 58.2 percent of full scale. Depending upon the output connections, this reading could be represented as either 58.2 millivolts or 0.582 milliampere.

The time interval selection covers the very broad range of 0.1 second or minute to 9999.9 seconds or minutes in increments of either 0.1 second or 0.1 minute, allowing "fine running" as it were

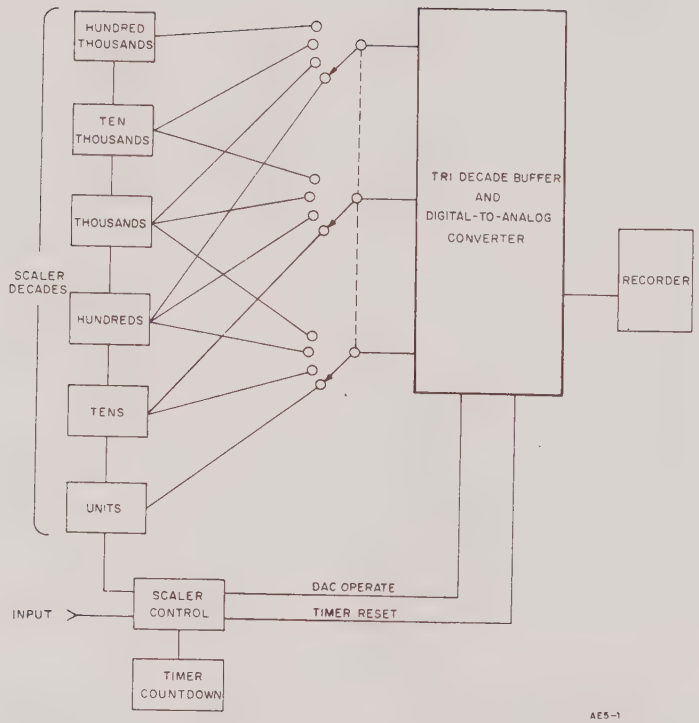


Figure 4-11. Partial Block Diagram of Model 530 Spectrometer Showing DAC Section

of the total counts accumulated per time interval. The counting rate is easily established by a simple computation of counts divided by the timer interval selected. In the channel advance mode the maximum timer interval available is 99.9 seconds or minutes, as selected by the front panel time base (0.1 SEC - 0.1 MIN) switch.

The x output on the rear terminal strip is provided to drive the x-axis of x-y recorder. This output, presented as a stop voltage consisting of 99 equal increments, ranges from approximately 0.9 volt to 9.7 volts negative. Since the output signal is taken from the same circuits which drive the spectrometer baseline in the AUTO mode, information pertaining to the channel advance (see Section VI, Operating Instructions) applies also to the x-drive.

It is possible to use a 10 millivolt recorder to permit scale expansion. One technique is to shunt the 100 ohm resistor with a second 100 ohm resistor so twice the normal full scale DAC current is required to drive a 100 millivolt recorder to full scale.

If a 10 millivolt recorder is connected across the DAC output, a full count of the two least significant decades can be used to drive the recorder to mid-scale. Twice the overflow will be required to drive the recorder to full scale.

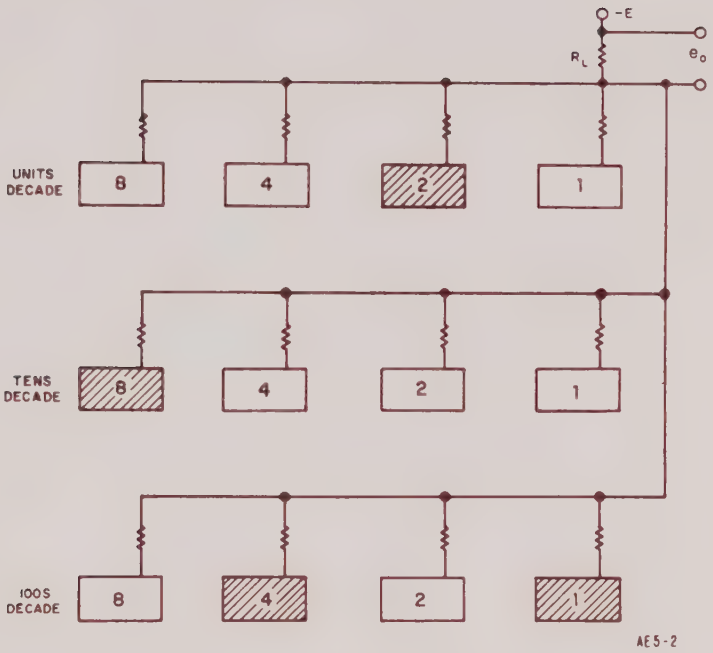


Figure 4-12. Block Diagram Showing How Analog Voltage is Developed

## SECTION V

## PERFORMANCE CHARACTERISTICS AND SPECIFICATIONS

### 5.1 INTRODUCTION

The published Spectrometer specifications are as fully important as the instrument description, for the data provided is necessary to correctly use the Model 530 (and 530A) Spectrometer. Baird-Atomic products benefit from a program of continuing evaluation and improvement; specifications are subject to modification.

### 5.2 SPECTROMETER SPECIFICATIONS

General

| | |
|---|---|
| Line Voltage | 115 volts ac ± 15%, 60 Hz (115 volts, 50 Hz, or 220 volts, 50 Hz option) |
| Input Current | 0.9A at 115 volts ac |
| Operating Temperature Range | +10°C to +50°C |

#### 5.2.1 Scaler-Timer

| | |
|---|---|
| Resolving Time | 1 μsec pulse pairs |
| Maximum Continuous Count Rate | 1 megacycle |
| Count Capacity | 999,999 |
| Input | (negative 5 volts, internal from analyzer) |
| Preset Counts | All decades presettable from 0 to 9 |
| Display | 0-9 (incandescent lamps) |
| Time Base | 0.1 second or 0.1 minute (derived from 60 Hz ac line) |
| Time Ranges | 0.1 - 9999.9 seconds in 0.1 second increments or 0.1 - 9999.9 minutes in 0.1 minute increments |
| Time Capacity | 5 decades presettable from 0 to 9 |

Controls

| | |
|---|---|
| Preset Count: | All decade presettable from 0 to 9 |
| Automatic/Manual/ Test Slide Switch Preset Time: | All decades presettable from 0 to 9 |
| Time Selector Switch | |
| Preset Count/Background Subtract Switch | |
| Start/Stop Pushbuttons | |

#### 5.2.2 Amplifier-Analyzer

#### 5.2.2.1 Analyzer

| | |
|---|---|
| Modes | |
| Discriminator | Integral or Differential |
| Baseline Advance | Manual or Automatic |
| Baseline Range | 0 % to 100 % |
| Window Range | 0 % or 100 % of full scale baseline range |
| Linearity | ±0.25 % of full scale at any setting |
| Input Polarity | Positive |
| Input Voltage Range | 0 - 10 volts |
| Input Impedance | 1,000 ohms (minimum) |
| Input Pulse Shape | Rise time not critical. Typical 0.1 to 0.5 μsec |
| Input Pulse Width | Not critical. Blanking inhibit level generated by upper level discriminator on leading edge. Removed only by action of lower level discriminator on trailing edge |
| Output Pulse | Negative 6 volts. 0.5 μsec wide |

| | |
|---|---|
| Output Impedance | Less than 100 ohms |
| Resolving Time | Less than 1.0 μsec |
| Baseline Temperature Stability | Manual Mode: 0.02% of full scale per °C. Automatic Mode: ±1 channel (1%) from 25°C to 50°C |
| Baseline Shift | 1% of full scale for 60,000 Hz average count rate |
| Controls: | |
| | Lower Level Potentiometer (0 to 100%) |
| | Window Potentiometer (0 to 100%) |
| | Manual/Automatic Control |
| | Integral/Differential Switch |

5.2.2.2 Amplifier

| | |
|---|---|
| Input Modes | |
| Current | |
| Maximum Gain | 10 volts/microampere |
| Input Sensitivity | 1 microampere (full scale) |
| Input Impedance | 100 ohms, approximately |
| Noise | 0.02 microampere rms referred to input |
| Pulse Shaping | 0.1 μsec input differentiating time constant |
| Output Pulse Shape | 0.25 μsec rise time, typical |
| Voltage | |
| Maximum Gain | 1000 |
| Input Sensitivity | 10 millivolts (full scale) |
| Input Polarity | Negative |
| Input Impedance | 10,000 ohms |
| Noise | 0.2 millivolt rms referred to input |
| Pulse Shaping | 10 μsec input differentiating time constant |
| Output Pulse Shape | 0.25 μsec rise time, typical (decay time is function of preamplifier pulse shaping) |
| Input Pulse Shape | Not critical |
| Output Impedance | 10 ohms, approximately |
| Voltage Range (nominal) | Positive 0 - 10 volts |
| Voltage Range (linear) | 150% of analyzer full scale input |
| Linearity | ±0.25% of full scale |
| Overload Recovery | Less than 10 μsec for a 100 to 1 overload |
| Gain Sensitivity to Temperature | 0.02% of full scale per °C |
| Resolving Time | 1 μsec |
| Controls | |
| Coarse Gain Control (Six Position) | |
| Fine Gain Control (50 to 100% of Coarse Range) | |

5.2.3 High Voltage Power Supply

| | |
|---|---|
| Circuit | All solid-state |
| Output | 500 to 2985 volts dc at 5 ma maximum |
| Polarity | Positive |
| Short Circuit Protection | Fused |
| Line Regulation | 0.01% maximum from 105 to 125 volts ac |
| Load Regulation | 0.01% maximum from 0 to full load |
| Noise and Ripple | 150 mv peak-to-peak |
| Stability | 0.03% per day maximum |
| Temperature Coefficient | ±0.005% of full scale per °C from 10°C to 50°C |
| Controls | |
| Coarse Adjust Swtich, 10 position | 500 to 1400 volts in 100 volts increments (1500 |

| | |
|---|---|
| | to 2850V in 150 volts increments for 3 KV range) |
| Fine Adjust Switch, 10 position | 0-90 volts in 10V increments (0-125 in 15V increments for 3 KV) |
| Range Selector Switch | 1.5KV/3KV |
| Power On/Standby Switch | |

## 5.3 CONNECTIONS

| | |
|---|---|
| Preamplifier | Amphenol 7-pin (3102A-16S-1S) Signal Input Ground<br>B +18 volts at 10 ma<br>-18 volts at 10 ma |
| Signal Current Input | MHV (input to amplifier for current mode) |
| Signal Voltage Input | BNC (input to amplifier for voltage mode) |
| Printer Readout | Amphenol 50-pin (57-40500) |
| (Scaler-Timer) | Contains all decade outputs, command signal for printer. BCD 1-2-4-8 output from each decade in Scaler and Timer.<br>One Level - 0.0 volt ±0.5 volt<br>Zero Level - Negative 10 volts ±2 volts<br>Print Command - A negative 15 volt pulse with a 45 millisecond decay that occurs when count stops.<br>Inhibit Start - Generated by Printer switch closure to ground occurring no more than 50 milliseconds after start of print command. Duration less than 200 milliseconds. |
| Analyzer Output | BNC (-6 volts 0.5 μsec wide) |
| Voltage Outputs | 1.5 KV high voltage output (MHV)<br>3 KV high voltage output (MHV) |
| AC Power | 115 volts ac 60 Hz at 850 ma (50 Hz optional) |

## 5.4 DIMENSIONS

| | |
|---|---|
| Size | 17 in. wide x 7 in. high x 15 in. deep |
| Weight | Approximately 38 pounds |

## 5.5 DAC SPECIFICATIONS

| | |
|---|---|
| Range Positions | 1 to 1 K, 10 to 10K, 100 to 100 K and 1 K to 1 M |
| Readout Intervals | 0.1 to 9999.9 sec. or min. (MAN); 0.1 to 99.9 sec. or min. (AUTO) in 0.1 second or minute increments |
| Dead Time | 0.2 second per readout (if printer is not used) |
| Output | 0 to 1 milliampere or 0 to 100 millivolts |
| Output Impedance | Approximately 10 ohms for 0 to 10 millivolts; approximately 1.5 kilohms for 0 to 1 milliamphere |
| X Drive Output | Approximately -0.9 volts at zero to approximately -9.7 volts at full scale |
| Maximum X Drive Current | 5 milliamperes |
| Accuracy | ±1% of full scale count |
| Stability | ±1% of full scale per day |
| Linearity | Less than ±3% of full scale over temperature range of 25°C to 50°C |

## 5.6 MODEL 620 PRINTER SPECIFICATIONS

Baird-Atomic offers the Model 620 Printer to be used with the Model 530 Spectrometer. Printer specifications are as follows.

| General | |
|---|---|
| Power | 115 volts ac ±10 %, 60 Hz approximately 0.7 A, 45 watts |
| Cable and Connector | Amphenol 50 pin (57-30500) |
| Printing and Connector | 3 lines per second maximum |
| Printing Format | Lists vertically on 4 in. wide adding machine tape. Column 1 to extreme right |
| Paper Requirements | 4 in. roll tape |
| Printing Ribbon | 5/16 in. black |
| Number of Columns Used | 11 |
| Maximum Column Capacity | 12 digit max. |
| Data Arrangement | Timer- column 12 to Column 8<br>Scaler - column 6 to column 1<br>For automatic baseline mode, columns 12 and 11 are used for channel numbers. |

| Inputs and Output | |
|---|---|
| Data Input Code | 4 line BCD 1-2-4-8 code. Parallel entry to all columns simultaneous with print command |
| Levels | Binary one - 0 ± 0.5 volts<br>Binary zero - -8 to -20 volts |
| Input Resistance | 10 megohms |
| Print Command | Change from binary one to binary zero, lasting for 40 milliseconds, starts print cycle |
| Inhibit Start | Generated by printer. Switch closure to ground occurring no more than 50 milliseconds after start of print command. Duration is less than 200 milliseconds |
| Dimensions: | |
| Portable Case | 9 in. wide x 10 in. high x 13 in. deep |
| Printer | 8 in. wide x 8 in. deep |
| Weight | Approximately 35 pounds (Shipping Weight: 45 pounds) |

# SECTION VI

# OPERATING INSTRUCTIONS

## 6.1 INTRODUCTION

The Models 530 and 530A Spectrometers are versatile instruments with several possible modes of operation. The operation procedures provided herein are intended to assist the operator in initial equipment setup (after installation) and as a reference for daily operation. It is recommended that the calibration checks outlined in Section VII, be performed daily, before commencing regular instrument or system operation.

All spectrometer controls and indicators are functionally located on the front panel (figure 6-1) with the exception of the HV RANGE, SPAN ADJUST and DAC RANGE controls which are located on the rear connector panel (figure 6-2). The Sample Timer IN-OUT switch used in conjunction with Sample-Timer operation is located behind the front panel. Table 6-1 outlines the function of the front panel controls and indicators.

All input and output connectors and fuses for the line and high voltage are mounted on the rear connector panel. Table 6-2 outlines the rear panel controls, fuses, and connectors. Table 6-3 lists the DAC controls and connectors also located on the rear panel.

## 6.2 GENERAL OPERATING PROCEDURES

The Model 530 Spectrometer has several possible operational modes. These operating procedures are intended as a guide only to assist the operator in initial setup. For clarity of this discussion, it is convenient to divide the spectrometer into its three major sections: Scaler-Timer, Amplifier-Analyzer, and High Voltage.

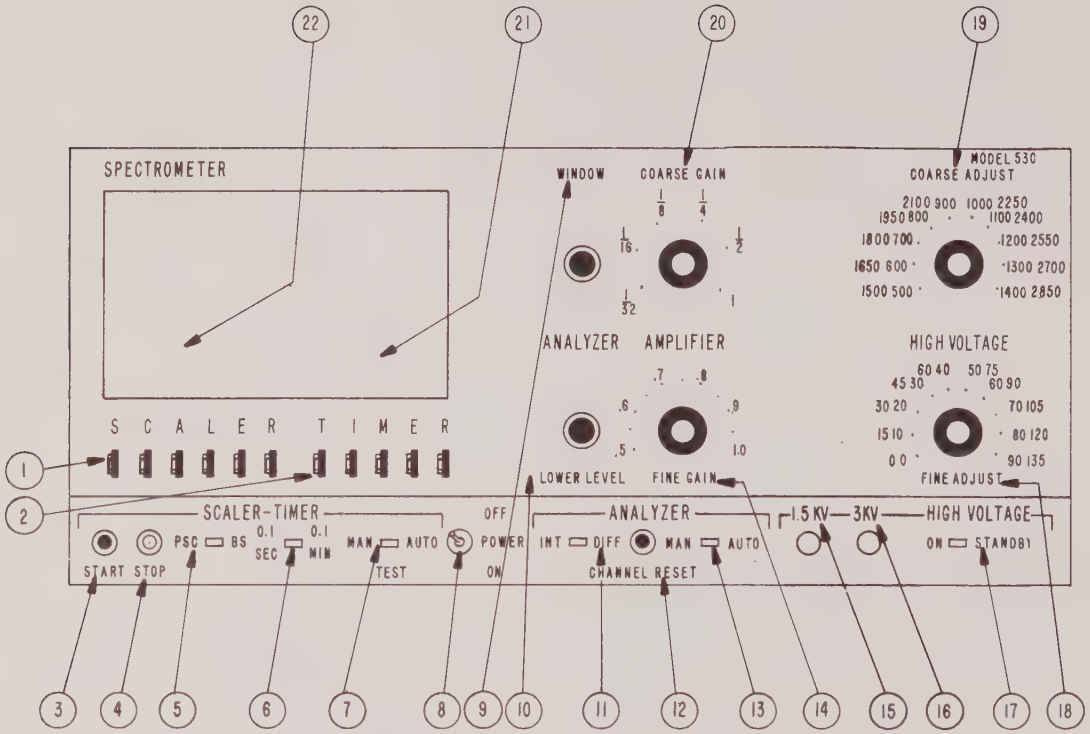


Figure 6-1. Front Panel Controls and Indicators

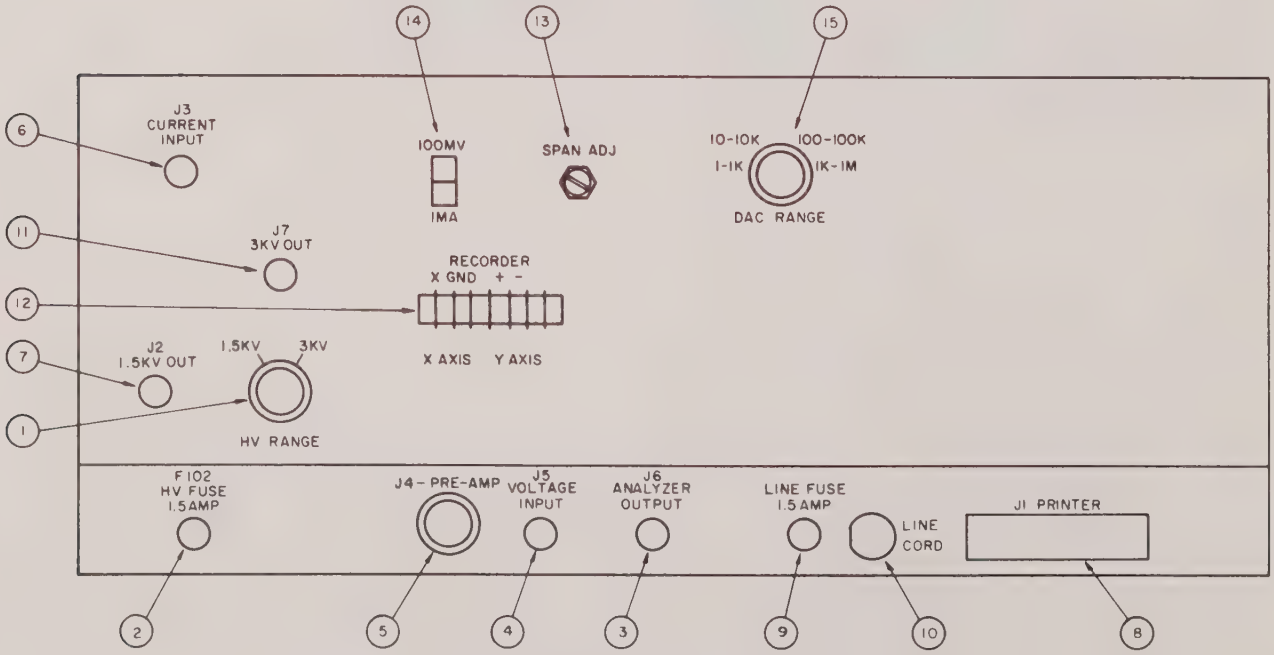


Figure 6-2. Rear Panel Controls, Fuses, and Connectors

Table 6-1. Front Panel Controls and Indicators (sheet 1 of 3) (see figure 6-1)

| REF NO. | CONTROL or INDICATOR | FUNCTION |
|---|---|---|
| 1 | SCALER (Present Count) | a) Stops scaler when count reaches preset number if PSC - BS switch is in PSC position.<br>b) Resets scaler to zero first time count reaches preset number if PSC - BS switch is in BS position. |
| 2 | TIMER (Preset Timer) | Stops scaler/timer when time reaches preset number; both PSC and PST are overriding type controls |
| 3 | START | Resets, then starts scaler/timer. |
| 4 | STOP | Stops scaler/timer synchronously. |
| 5 | PSC-BS | Slide Switch - PSC for preset count, BS for background subtract |
| 6 | 0.1 - 0.1<br>SEC MIN | Selects time base for timer. |
| 7 | MAN-AUTO | a) MANual - scaler/timer under control of START-STOP pushbuttons.<br>b) AUTOmatic - scaler/timer stops on PST or PSC, waits for printer to print, then automatically resets and starts.<br>c) TEST - timer clock base applied to scaler as test input. |
| 8 | OFF<br>POWER<br>ON | Connects 115 volts ac, 60 Hz line voltage to spectrometer (system supply). |
| 9 | WINDOW | Controls window width when INT-DIFF switch is in DIFF; setting from 0 to 100% of full scale input (10 volts). |
| 10 | LOWER LEVEL | Controls baseline discrimination level from 0 to 100% when MAN-AUTO switch is in MAN. |
| 11 | INT-DIFF | a) INTegral - Disables WINDOW control: output pulse occurs when input pulse exceeds lower level discriminator. |

Table 6-1. Front Panel Controls and Indicators (sheet 2 of 3)

| REF NO. | CONTROL or INDICATOR | FUNCTION |
|---|---|---|
| 11 (cont.) | | b) DIFFerential - output pulse occurs when input pulse falls within window determined by WINDOW and LOWER LEVEL controls. |
| 12 | CHANNEL RESET | Resets baseline to channel 00; used only when MAN-AUTO switch is in AUTO. |
| 13 | MAN-AUTO | a) MAN - baseline discrimination level controlled manually by means of LOWER LEVEL potentiometer.<br>b) AUTO- baseline discrimination level controlled and advanced automatically by means of digital-to-analog converter; baseline steps through 100 channels in 1% increments. |
| 14 | FINE GAIN 1.0 - 0.5 | Multiplier for COARSE GAIN switch; allows continuous setting between coarse ranges. |
| 15 | 1.5 KV Lamp | Pilot lamp; indicates that power is being applied when lighted. |
| 16 | 3 KV Lamp | Pilot lamp; indicates that power is being applied when lighted. |
| 17 | ON-STANDBY | a) ON - high voltage connected to output connector.<br>b) STANDBY - disconnects low voltage from transformer primary center tap; secondary still connected to one of the output connectors. |
| 18 | FINE ADJUST 0 - 90 volts and 0 - 135 volts | Adjust voltage in 10-volt steps (1.5 KV Range) or adjust voltage in 15-volt steps (3 KV Range), reading adds to COARSE ADJUST reading. |
| 19 | COARSE ADJUST | Adjusts voltage in 100 volt steps (1.5 KV Range), or adjusts voltage in 150 volt steps (3 KV Range). |
| 20 | COARSE GAIN $1 - \frac{1}{32}$ | Changes amplifier gain in binary-steps from 1 to 1/32; where 1 is equivalent to amplifier voltage gain of 1000 or current gain of 10 volts per microampere. |
| 21 | TIMER | Indicates five digits of total elapsed time since last scaler start pulse; least significant digit is 0.1 |

Table 6-1. Front Panel Controls and Indicators (sheet 3 of 3)

| REF. NO. | CONTROL INDICATOR | FUNCTION |
|---|---|---|
| 21 (cont.) | | second or 0.1 minute depending upon position of time base switch; if analyzer MAN-AUTO switch is in AUTO, the first two digits represent baseline channel number as percent of full scale rather than most significant digits of timer; if SAMPLE CHANGER switch is set to IN the first two digits represent sample number. |
| 22 | SCALER | Indicates total count in scaler decades, most significant digit is furthermost to left.. |

Table 6-2. Rear Panel Controls, Fuses, and Connectors (sheet 1 of 2)

| REF. NO. | CONTROL, FUSE or CONNECTOR | FUNCTION |
|---|---|---|
| 1 | 1.5 KV - 3 KV HV RANGE | Selects 1.5 KV or 3 KV range from power supply. |
| 2 | F102 H.V. FUSE 1.5 AMP (High Voltage Power Supply) | Fuses - 18 volt supply to series regulator that drives high voltage transformer primary center tap. |
| 3 | J6 ANALYZER OUTPUT (Analyzer) | Connects directly to analyzer output; 0.5 micro-second, 6 volt negative-going pulse from ground. |
| 4 | J5 VOLTAGE INPUT (Amplifier) | AC coupled to high impedance voltage input of amplifier; parallel J4 signal input; normally connected to preamplifier output. |
| 5 | J4 PRE-AMP (Amplifier) | AC coupled to high impedance voltage input of amplifier; contains ±18 volts dc, 10 ma, to supply preamplifier power; may be connected directly to any standard Baird-Atomic scintillation probes and well counters containing a preamplifier. |

Table 6-2. Rear Panel Controls, Fuses, and Connectors (sheet 2 of 2)

| REF NO. | CONTROL, FUSE or CONNECTOR | FUNCTION |
|---|---|---|
| 6 | J3<br>CURRENT<br>INPUT<br>(Amplifier) | AC coupled to low impedance current input of amplifier; may be connected directly to phototube anode with maximum dc level of 3000 volts. |
| 7 | J2<br>1.5 KV OUT<br>(High Voltage Power Supply) | Connects to source of high voltage; 1500 volts dc maximum. |
| 8 | J-1 PRINTER<br>(Scaler-Timer) | Connects to 4-line output of each of the six scaler and five timer decades; also contains control signals for Model 620 Printer and Sample Changer. |
| 9 | F101<br>LINE FUSE<br>1.5 AMP | Primary line fuse |
| 10 | LINE<br>CORD<br>(System Supply) | Connects to power outlet; normally 115 volts ac, 60 Hz, the third wire tied to equipment ground. |
| 11 | J7<br>3 KV OUT | Connects to source of high voltage; 3000 volts, dc maximum. |

Table 6-3. DAC Controls and Connectors (see figure 6-2)

| REF NO. | CONTROL or CONNECTOR | FUNCTION |
|---|---|---|
| 12 | RECORDER | Input connections to accessory equipment are made on this connector. |
| 13 | SPAN ADJ | Calibrates recorder full scale. |
| 14 | 100 MV - 1 MA | Selects either of two recorder operations: 0 to 1 milliampere or 0 to 100 millivolts full scale (with 0 to 10 millivolts optional). |
| 15 | DAC RANGE | Selects the three adjacent scaler decades for read-out by the DAC card. |

CAUTION

Do not place any materials (books, papers, magazines etc.) on top of the instrument that would tend to block air circulation. Heat trapped in the spectrometer has a detrimental effect on the electronics.

CAUTION

Avoid leaving decade lamps at a constant readout. It will shorten their operating life expectancy. It is recommended that the timer and scaler thumbwheel switches both be set for all nines (9's), and the time mode be set to 0.1 minutes with the MAN-TEST-AUTO switch on the scaler set to TEST. Push START push-button for long time count on both scaler and timer to even distribution of lamp displays between laboratory tests.

## 6.3 SCALER/TIMER

The scaler/timer contains three mode switches that must be set up, as well as the 11 thumbwheel switches for presetting count or time. The time base for the timer is selectable in 0.1 second or 0.1 minute increments. The total range of the timer can be 9999.9 seconds or 9999.9 minutes. The PSC-BS switch selects the use of the scaler thumbwheel switches for either preset count (PSC) or for background subtract (BS) function. The three-position MAN-AUTO-TEST switch determines whether the scaler will start and stop automatically or be under control of the pushbuttons. In TEST, the timer clock base is applied as an input to the scaler for checking its operation.

Preset time and preset count controls work on an overriding basis. The scaler will stop on whichever preset number is arrived at first. When it is desirable to stop on preset time, set the desired time interval into the timer switches. If background subtract is not to be used, set the PSC-BS to the PSC position and set the scaler thumbwheel switches to all nines. Then the scaler will stop on the number preset in the timer. If activity is greater than anticipated and the full scale capacity is reached before the time that was preset, the scaler stops when the preset count of 999,999 is reached. The operator will then still get a valid reading. If the scaler did not stop when at full scale, the operator would have no positive reference for it.

When it is desirable to stop on a preset count to ensure sufficient statistical accuracy, preset the count in the scaler switches, put the PSC-BS switch in PSC position, and preset all nines in the timer switches. The scaler will then continue to count until it reaches the preset count; if the activity is less than expected, it counts until it reaches the preset time. Sometimes it may be necessary to establish both a preset count and a preset time. For example, if it is desirable to automatically print out a spectrum with one percent statistical accuracy at each baseline setting, one percent accuracy requires that 10,000 counts be accumulated. In the region of the photopeak, assume that 10,000 counts can be obtained in a reasonable time. However, in the valley before the peak, it may take an exorbitantly long time to reach this count. It is desirable in this situation to preset a maximum time that the spectrometer should dwell at any setting. Since the controls are overriding this is done simply be setting in the preset count and time wanted. When either preset time or preset count is not to be used, always set up switches to a high number: all nines, say, to disable it.

NOTE

Never set all switches to zero, for this results in an invalid stop.

When the scaler is stopped with the preset count control, it is normally synchronized to the timer. So when the preset count is reached it does not immediately stop the scaler, but conditions it so that the next timer clock pulse will stop it. Since the clock pulse occurs in either 0.1 second or 0.1 minute intervals, it is possible to accumulate

further counts while waiting for the stop signal. But when the scaler does stop, it will show the exact number of counts that occurred in the time interval displayed.

Synchronized preset count is more precise than nonsychronous. But when it is desirable to stop on the exact number preset in the scaler, simply add one jumper to the scaler control card to disable the synchronous feature. (See figure 4-10.) (The nonsynchronous preset count option is discussed below.)

The background subtract feature is used when it is desirable to obtain a final count which is above the present background. In determining the background, connect the detector and phototube to the spectrometer, remove the radioactive source and measure the count rate present for some time. Calculate total counts expected during the actual test by multiplying the count rate by the number of minutes or seconds that the test will be conducted. Then preset the time, put PSC-BS switch in the BS position, preset expected background in scaler switches, replace source and start the scaler. The scaler will count until it reaches the number in the thumbwheel switches. When this number is reached, the scaler only, will reset and then continue to count. Meanwhile, the timer will continue until it reaches the preset time; it will then stop the scaler. In background subtract mode, the scaler/timer can be stopped only be preset time or manual stop.

When the three-position mode switch is in MAN, the scaler is started with the START pushbutton, actually a reset-start operation, since both the scaler and timer are reset to ZERO before starting. The stop function is accomplished by preset count, preset time or manual stop, whichever occurs first. If a printer is connected to the spectrometer, the contents of the timer and scaler at the end of the counting cycle are printed out in parallel each time the scaler is stopped.

When the mode switch is in AUTO the scaler resets, starts and stops automatically. When either preset time or count is reached the scaler stops. If no printer is connected, the first clock pulse causes the scaler to reset and start. When a printer is connected, a print command signal, generated when stopping the scaler, starts the printing cycle. The printer returns an inhibit start signal, taking from 200 to 250 milliseconds, which prevents the scaler from starting until the printer no longer requires the input data. Two clock pulses after the end of the inhibit start, restart the scaler. When the time base for the timer is 0.1 second, the total time the scaler is stopped varies between 0.3 and 0.4 second. When the time base is 0.1 minute, the scaler is always stopped for two clock periods which is 12 seconds.

NOTE

When it is desirable to stop the scaler and prevent it from restarting, the mode switch must be moved from AUTO to MAN.

In TEST, the input from the analyzer is disconnected and the timer clock base instead is connected to the scaler input. The scaler/timer always operates under MANual control when in TEST. Since the same signal is driving both scaler and timer, the two counters will operate in unison. If the instrument stops on preset time, the numbers displayed on the scaler and timer will match the present time number. If, instead, preset count does the stopping, the number displayed will be one higher than that set in the switches. Since preset count is synchronized, a conditioning signal only is generated when the count is reached in the scaler. The actual stop signal is the next clock pulse: in TEST it is also the input to the scaler.

If the nonsynchronized preset count option is employed, the scaler/timer stops immediately upon reaching the preset number. Then the display will coincide with the thumbwheel switch number settings.

## 6.4 AMPLIFIER/ANALYZER

### 6.4.1 Amplifier

The amplifier allows the operator the option of a low input impedance current input, or a high impedance voltage input. The current input allows the phototube to be connected with up to 25 feet of coaxial cable to the amplifier with no intermediary preamplifier. It also allows several

tubes to be summed directly into one amplifier. A high voltage capacitor is included in the amplifier input to allow up to 3000 volts dc level to be present at the input. The voltage input of the amplifier is used in conventional fashion, that is, driven from the low output impedance of a pre-amplifier. The input circuit consists of capacitor coupling into a 10,000 ohm resistor.

The phototube is connected to the CURRENT INPUT connector J3, an MHV connector. The preamplifier may be connected to PRE-AMP connector J4, a 7-pin Amphenol if it is a standard Baird-Atomic preamplifier, or to VOLTAGE INPUT connector J5, a BNC connector. When using the CURRENT INPUT connector J3 the voltage input may be left floating. When using VOLTAGE INPUT J5, CURRENT INPUT J3 should be left open if not in use.

There are two amplifier gain controls: a COARSE GAIN which varies the gain by factors of two in six steps, and a FINE GAIN which is a one turn potentiometer. The range of adjustment is from one-half to one times the COARSE GAIN setting, allowing continuous adjustment from the lowest to the highest gain settings. The maximum gain is 1000 for the voltage input, and 10 volts per microampere for the current input.

### 6.4.2 Analyzer

There are two mode switches for the analyzer: The INT-DIFF switch selects integral or differential operation; the MAN-AUTO switch selects either MAN or AUTO baseline advance. In INT an output appears from the analyzer whenever an input pulse exceeds the lower level discrimination level. In DIFF, an output appears whenever the input pulse exceeds the lower level discrimination level, but not the upper level, as determined by the WINDOW setting.

In MAN the baseline discrimination level is determined by the setting of the LOWER LEVEL 10-turn potentiometer. In AUTO the base-line discrimination level is determined automatically by an all solid-state digital-to-analog converter. Here the two decade counters normally used for the two most significant digits of the timer indicate instead the channel number as a percentage of full scale. The output of the digit channel counter is converted to 100 discrete voltage steps from 0 to 99 % of full scale by means of a digital-to-analog converter. The LOWER LEVEL potentiometer has no function in this mode. The channel counter advances by one each time the scaler/timer is started. The baseline voltage then remains constant at the value indicated by the channel counter while counts are accumulated in the scaler. The baseline remains at this level until the scaler stops, then starts again. The CHANNEL RESET pushbutton allows the channel counter to be reset to zero at any time. When the analyzer is in AUTO the two thumbwheel switches associated with the channel counter are disconnected from their normal role as part of preset time control. They may be at any arbitrary setting without affecting the operation.

The automatic baseline feature allows a complete spectrum to be printed out automatically. Set the analyzer to AUTO and reset the channel counter. Preset either time or count (or both) in the Scaler-Timer and set the scaler/timer to AUTO.

The scaler will automatically start, advancing the channel counter to one percent. Counts are accumulated until either preset time or count is reached, then the scaler stops. If a printer is connected, the contents of the 2-digit channel counter, 3 digits of time and 6 digits of count are printed out. When the printer no longer requires the information the scaler resets, the channel counter advances to channel two, and then the scaler restarts. In this manner a complete 100 channel spectrum may be automatically printed out.

If it is desirable to advance to a particular channel rapidly, and then to remain there, or to more slowly advance beyond the channel, set the preset time for the shortest period (0.1 second); set the scaler to AUTO; the printer to STANDBY. The baseline will advance rapidly: 0.3 second per channel. When approaching the desired setting, switch the scaler to MAN which will cause the scaler to stop. Now set for desired preset time or count, set printer to PRINT and return scaler to AUTO. A partial spectrum may then be printed in the region of greatest interest. After the channel counter reaches 99 it will reset to zero on the next start signal, repeating the spectrum until the scaler is permanently stopped by setting it to MAN.

## 6.5 HIGH VOLTAGE

The high voltage may be applied to the phototube by means of MHV connector J2 (1.5 KV OUT). Detectors requiring more than 1500 volts must be connected to J7 (3 KV OUT).

There is one mode switch for the high voltage, ON-STANDBY. In the ON position the voltage indicated by the front panel switches position will be present at the J2 or J7 connector. In the STANDBY position the primary center tap of the high voltage transformer is connected to ground rather than to a regulated dc voltage. The secondary remains connected to J2 and J7 with zero volts across it in the STANDBY condition. Of the two front panel controls of the high voltage (table 6-1), the setting of FINE ADJUST is added to the COARSE ADJUST which sums up to the exact voltage appearing at connectors J2 of J7.

The supply is protected against short circuit by means of fuse F102 (located on the rear connector panel). The fuse is in series with the -18 volt regulator connected to the primary center tap. Because of this no high voltage is present at the fuse terminals.

## 6.6 50 Hz OPERATION OPTION

The Model 530 Spectrometer is supplied to be operated with a 115 volt, 60 Hz power source, but 50 Hz operation at 115 volts, or 220 volts are offered as options. The only component difference between a spectrometer using the 60 Hz power source, or one using the 50 Hz source is in the system power supply transformer.

Since the frequency source for the timer is derived from the line voltage, it is necessary to make a change also on the timer countdown card, C8 (figure 4-1). The change from 60 to 50 Hz operation is done simply by changing the location of one jumper. (Baird-Atomic Timer Countdown Schematic D-30181 and Component Layout C-30186 give full details on the jumper change.)

## 6.7 PROPORTIONAL COUNTER SPECTRUM APPLICATION

Although the general operating procedures have been concerned with scintillation spectrometer applications, the same general procedure can be employed to obtain a proportional counter spectrum.

Typical settings for plotting the 14.4 KEV peak of a $^{57}Co$ spectrum with a proportional tube using 90% xenon - 10 % methane fill are as follows:

a. Preamplifier gain set at x10.

b. HV set at 2030 volts.

c. AMPLIFIER FINE GAIN set at 0.5.

d. AMPLIFIER COARSE GAIN set at 1/4.

e. ANALYZER WINDOW = 1 %

The counter input cable to the preamplifier should be approximately 7-1/2 in length. The resolution of the 14.4 KEV photopeak obtained with this application should be approximately 12 percent.

A photopeak is obtainable using the current input mode but the resolution (tests show), is much poorer on account of increased noise caused by the cable (maximum gain of 1000 is necessary as well as higher voltage for this mode of operation) and the input pulse characteristic.

## 6.8 SAMPLE CHANGER

The Sample Changer switch S11 (see Section X, Figure 10-2) when set to IN places the spectrometer under the control of a Sample Changer: when the switch is set to OUT, operation remains as described above.

For Sample Changer operation set the Sample Changer switch to IN, the analyzer to AUTO, and the scaler-timer to AUTO. In this mode the baseline is set manually with the LOWER LEVEL control.

The last two timer decades indicate sample number rather than time. Control signals from the sample changer unit are brought in through the 50-pin Printer connector, J1 (see figure 6-2 and table 6-2). Two control signals, the Index Advance and Index Reset, synchronize the two sample counter decades to the sample number being analyzed. A third control lead provides the Inhibit Start signal to the scaler control which prevents the counting operation until the sample is correctly positioned.

## 6.9 NONSYNCHRONOUS PRESET COUNT OPTION

Normally the spectrometer is supplied with synchronous preset count. When the scaler arrives at the preset count it is conditioned to stop but does not actually stop until the next clock pulse comes from the timer. Then the exact counts per unit time are displayed. Since some operators prefer not to have synchronized preset count (so the scaler will stop on the exact count preset), an option is provided which disables the synchronous feature. Figure 4-10 shows how the change may be made on the scaler control card merely by adding a jumper between A and B.

## 6.10 OPERATING PROCEDURES WITH DAC-EQUIPPED MODEL 530A

Operation of the Model 530 Spectrometer as a digital ratemeter in no way affects its normal operation. Available Spectrometer operating modes are unimpaired while remaining useful for extending spectrometer utility as a digital ratemeter by insertion of the DAC printed circuit card into card position C14.

Counting rate can be monitored by a recorder just as with a conventional ratemeter, and presentation will be made in stepwise fashion, indicating the actual counts per reading (within one percent) instead of the random statistical fluctuations of the conventional recorder.

Selection of the DAC range is simplified by consulting table 6-4 which illustrates the scaler decades as they are observed from the front of the Spectrometer. Note that the DAC RANGE positions shown in figure 6-2 indicate the applicable total count range less one count. In range 10 - 10K, for example, although it is possible to accumulate a greater or fewer number of counts, the actual range covered by the DAC section is from 10 counts to 9999 counts. The last digit in each case is not registered as part of the analog output. The same considerations are applied to the remaining range positions.

In table 6-4 the boxes designated with an X indicate that any digits may appear without having an effect on the analog output; if digits other than zero appear in the unmarked boxes an overflow has taken place and the analog reading is in error. When a printer is used simultaneously with the DAC, the numbers registered by the printer will be a true reading unaffected by overflow or other inherent errors in the DAC section.

Counting time or time constant for operation as a digital ratemeter is controlled by scaler-timer switch settings.

The background subtract feature in the Model 530 can be made a part of the digital ratemeter operation; resultant recorder trace will simply show the total count less a fixed number of counts as determined by the preset count (PSC) switch (see figure 6-3).

The only limitation imposed by the digital ratemeter is that it can read only the three most significant digits of the total count. If the maximum total count is exceeded, the surplus will not be recorded and a false reading will result.

In most cases, this condition is not intolerable because it is readily identified by previous knowledge of the character of the source. Assuming an average reading of 90 to 99 percent of full scale, if an occasional reading is suddenly recorded in the range of 0 to 10 percent an overflow has resulted. The extrapolated reading can be assumed by adding 10 in front of the total counts. As an example, if the average counts per time interval were 950 and the recorder suddenly showed a reading of 16, the total would be taken as 1016 counts.

This situation can be avoided by changing

the time interval to a shorter time or advancing the DAC switch by one position and increasing the preset time for a total counts reading nearer 50 of the most significant decade counting.

In plotting a spectrum it may be necessary to tolerate overflow for the first few stops of the plot to obtain a substantial reading of the photopeak. Aside from appearance, this does not detract from the plot since noise is still being counted in this region. Figures 6-4 and 6-5 show typical spectra for $^{137}Cs$. In figure 6-5 note the very low readings resulting from overflow at the start of the spectrum.

Table 6-4. Scaler Decade/DAC Range Switch Position Relationship

| | COUNTS DECADE POSITIONS | | | | | | |
|---|---|---|---|---|---|---|---|
| COUNTS | 100Ks | 10Ks | 1Ks | 100S | Tens | Units | SWITCH POSITIONS |
| From | | | | 0 | 0 | 0 | 1-1K |
| To | | | | 9 | 9 | 9 | |
| From | | | 0 | 0 | 1 | X | 10-10K |
| To | | | 9 | 9 | 9 | X | |
| From | | 0 | 0 | 1 | X | X | 100-100K |
| To | | 9 | 9 | 9 | X | X | |
| From | 0 | 0 | 1 | X | X | X | 1K-1M |
| To | 9 | 9 | 9 | X | X | X | |

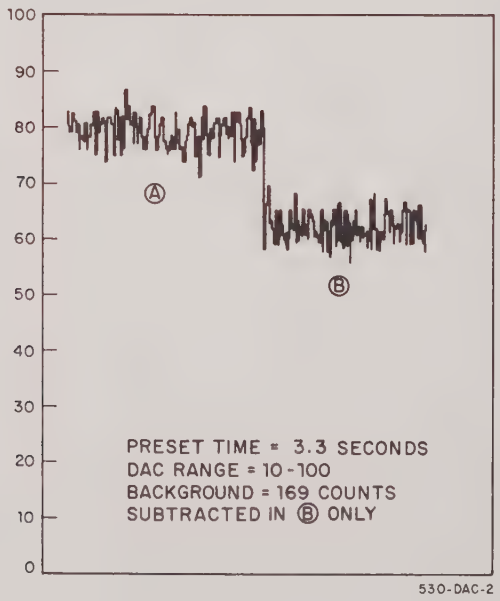


Figure 6-3. Typical Plot before and after Background Subtract for the Two Least Significant Decades and a 10 mV Recorder

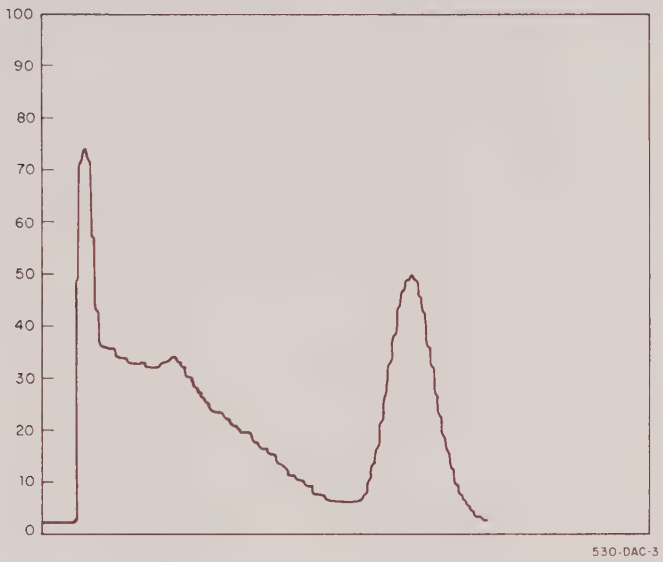


Figure 6-4. $^{137}Cs$ Spectrum Taken with Model 530 DAC

Figure 6-5. $^{137}Cs$ Spectrum Using Model 530 DAC, Showing Overflow

# SECTION VII

# CALIBRATION PROCEDURES INCLUDING MATERIALS AND EQUIPMENT TO BE USED

## 7.1 INTRODUCTION

The system calibration information set forth in this section outlines the procedures necessary for the calibration of the Spectrometer, Digital-to-Analog Converter (DAC), and X-Y Recorder. The system is calibrated directly in energy. No other equipment is required to perform system calibration. It is recommended that these procedures be performed daily to ensure stable system operation. A Baird-Atomic field engineer should check overall 530 (530A) performance as well as internal calibration a minimum of every six months.

## 7.2 SPECTROMETER CALIBRATION

Set up the spectrometer controls as follows:

A. Set SCALER to PSC, 0.1 SEC, MAN mode.

B. Preset a high count and long time in switches.

C. Place ANALYZER in INT position and the AUTO-MAN mode switch to MAN.

D. Set the HIGH VOLTAGE switch to STANDBY.

E. Connect high voltage cable to phototube and connect phototube to AMPLIFIER, either directly CURRENT INPUT jack J3 or via preamplifier to PRE-AMP jack J4 or VOLTAGE INPUT jack J5.

F. Set HIGH VOLTAGE switch to ON.

G. Using a standard source, set LOWER LEVEL control to correspond to isotope photopeak. For example, if $^{137}Cs$ is used, set LOWER LEVEL to 65.2% of full scale; set HIGH VOLTAGE to about 750 volts.

H. Set AMPLIFIER gain at minimum; COARSE GAIN at 1/16 and FINE GAIN at 0.75.

I. Press START button and observe SCALER as the COARSE ADJUST H. V. switch is increased.

When the SCALER starts counting, return to the previous COARSE ADJUST H. V. setting and vary the FINE GAIN control of AMPLIFIER until activity just begins in the SCALER. To get the exact setting, now place analyzer in DIFF, set 2% window, and adjust FINE GAIN for maximum counting rate in SCALER. Once set, the FINE GAIN control can be locked into position. To check the setting, set ANALYZER in AUTO/WINDOW to 1%, preset time for 0.1 second, set SCALER in AUTO, and print out a fast spectrum. It takes less than 40 seconds to print out a complete spectrum in this fashion; the operator can then rapidly obtain a complete check.

## 7.3 DAC CALIBRATION

Although the DAC section was tested and calibration at the factory for use with a recorder, it may be necessary to recalibrate the unit to correct for differences existing between the factory test recorder and a different recorder. Referring to figures 6-1 and 6-2, Section VI, recalibrate the DAC section in the following manner:

A. Set the recorder input switch to either 100 millivolts or 1 milliampere depending on the type of recorder used.

B. Connect the recorder, either 0 to 1 milliampere or 0 to 100 millivolts, across the minus (-) and plus (+) terminals on the RECORDER terminal strip.

C. Turn ON the spectrometer and calibrate the SPAN ADJ control on the rear panel as follows:

1. Set the SCALER-TIMER and ANALYZER mode switches to the MAN position; set the DAC RANGE switch in any position, preferably one of the higher positions; and reduce the AMPLIFIER gain so that the SCALER will not register noise counts.

2. Set the HIGH VOLTAGE switch to STANDBY.

Then, in turn, depress the START button and the STOP button. There should be zero counts on the SCALER but the recorder will assume some arbitrary position based on the previous counts reading. Ignore this reading.

3. Depress the START button again. The recorder should read zero. If it does not, adjust the recorder zero set control.

4. Set the SCALER-TIMER mode switch to TEST, the DAC RANGE switch on the 1-1 K position, the time switch on 0.1 SEC, the preset time switches to 99.9, and the preset count switches to any value higher than 1000.

5. Depress the START button. When 99.9 seconds have elapsed the SCALER-TIMER should stop counting at 999 counts.

6. Depress the START button and set the SPAN ADJ control for a recorder reading of 100 % of full scale to correspond with the observed reading on the SCALER.

The DAC section is now calibrated and ready for use.

## 7.4 X-Y RECORDER CALIBRATION

If an X-Y recorder is used, the calibration procedure for the Y-axis input is the same as that described above. Calibrate the X-axis input in the following manner:

A. Connect the recorder X-axis input terminals to the Model 530 Spectrometer terminals marked X and GND.

NOTE

Observe the proper polarity and range of the recorder in use.

B. Set the ANALYZER MAN-AUTO switch to AUTO and depress the CHANNEL RESET pushbutton. The two most significant digits in the TIMER will drop to zero.

C. Adjust the Recorder X-axis zero set control for Recorder zero.

D. Set the Spectrometer SEC-MIN switch to the 0.1 SEC position and set the preset time to 0.1.

E. Set the MAN-TEST-AUTO switch to the AUTO position. The TIMER should now repeatedly count to 0.1 (present time), and reset. With each cycle the channel decades (the two most significant digits of the timer section) should advance one digit and the Recorder X-axis should advance in equal increments across the sheet with a magnitude depending on the recorder gain settings.

F. When the channel number has just exceeded 90, set the MAN-TEST-AUTO switch to the MAN position, and advance the channel number manually by depressing the START pushbutton after each preset time cycle until channel number 99 is reached.

G. Start the SCALER once more and adjust the RECORDER gain control for a reading of 99 % of full scale.

## SECTION VIII

## OPERATIONAL PRECAUTIONS AND LIMITATIONS

The Model 530 Spectrometer is a precision laboratory instrument and as such should not be abused. The following precaution, taken during daily operation should be followed to ensure trouble-free instrument operation.

### CAUTION

Avoid leaving decade lamps on spectrometer at a constant read-out. It will shorten their operating life expectancy. It is recommended that the following steps be taken if the spectrometer is to be left on for any length of time between countings.

A. Set the thumbwheel switches on the SCALER and TIMER to all nines (9's).

B. Set the time mode to 0.1 MINutes.

C. Set the HIGH VOLTAGE switch to ON.

D. Set the COARSE and FINE GAIN switches to settings normally used for single counting.

E. Push the START pushbutton for long-time count on both SCALER and TIMER to even distribution of lamp displays between laboratory tests.

# SECTION IX
# HAZARDS

## 9.1 INTRODUCTION

The Model 530 Spectrometer is an electronic type instrument and the only hazards involved will be of an electrical nature, and then only while performing instrument maintenance. However, the spectrometer is often used in instrument systems where radioactive type material may be encountered. Therefore, the radiation precaution outlined in paragraph 9.2 is included herein for that reason.

## 9.2 HAZARDS

WARNING

This equipment contains voltage dangerous to human life and can cause death on contact. Take the following precautions when the front panel is opened: (see figure 10-2) .

A. Be sure the red plastic protective cover is on the COARSE ADJUST switch.

B. Never insert or extract extender cards while power is on.

C. All points that are subject to high voltage are located in the right side of the Spectrometer behind the front panel.

D. High voltage may also be present on the amplifier card (C18) if the amplifier current input is being used. Be sure all power is off before putting amplifier card on an extender.

## 9.3 SAFETY PRECAUTIONS WHILE HANDLING RADIOISOTOPES

Many laboratory substances (acids, alkalies, poisons, etc.) require careful handling; radioactive materials are no exception. Proper care and common sense should always be practiced in the laboratory. Under care, the following rules apply.

A. Wear surgeon's rubber gloves when working with all unsealed radioactive materials.

B. Handle liquid radioactive materials over a tray lined with absorbent paper to localize spills.

C. Mark all vessels containing radioactive materials (liquid or solid) with the approved radiation symbol.

D. Before removing the rubber gloves, wash them with generous quantities of soap and water.

E. When manipulating radioactive sources, liquid or solid, don't allow the hands to come in direct contract with them. Use a pair of forceps. Wash hands after every experiment.

# SECTION X

# USER SERVICE AND MAINTENANCE INFORMATION

## 10.1 INTRODUCTION

This section contains the information necessary to perform preventive maintenance checks as well as troubleshooting procedures for the Model 530 Spectrometer.

## 10.2 PERIODIC INSPECTION MAINTENANCE

Periodic inspection will often result in the discovery of a possible source of future trouble. Corrective action taken at this time will maintain efficient Spectrometer operation. Table 10-1 sets forth the items that are to be periodically inspected as well as the frequency at which they should be inspected. In cases where the operator is authorized to take corrective action, the "Disposition" column sets forth instructions. All other dispositions direct the operator to notify the responsible Baird-Atomic Field Representative.

## 10.3 TROUBLESHOOTING

The Spectrometer is constructed so that troubleshooting can be performed without removing the card cage from its cabinet or the cabinet from the rack, if rack mounted. Card locations are shown in figure 10-1. All printed circuit cards are accessible from the front merely by lowering the hinged front panel (see figure 10-2). Troubleshooting extender cards, which plug into any of the PC card connectors are available and have a 23-pin female connector mounted on the edge closest to the front panel to accommodate any of the printed circuit cards. This allows troubleshooting on the PC card while it is still connected.

## 10.4 SAFETY-HIGH VOLTAGE DANGER POINTS

It is the responsibility of the technician to know what and where the danger points (see figure 10-2) are in the spectrometer so he can avoid them when working on the unit with the power ON. In the event that a high voltage circuit must be tested or worked on while energized, the technician should consult the Spectrometer Logic Diagram (figure 4-1) and the High Voltage Power Supply Schematic Diagram (figure 4-2) in Section IV to determine the potential and location of the high voltage. For further confirmation a voltmeter should be connected across the circuit in question.

Refer to Section IV and the logic diagrams included in it to isolate and clarify any technical problems. If trouble in the spectrometer cannot be located and repaired, contact the nearest Baird-Atomic office.

WARNING

This equipment contains voltage dangerous to human life and can cause death on contact. Take the following precautions when the front panel is opened:

Be sure the red plastic protective cover is on the COARSE ADJUST switch (see figure 10-2).

Never insert or extract extender cards while power is on.

All points that are subject to high voltage are located in the right side of the spectrometer behind the front panel.

High voltage may also be present on the amplifier card (C18) if the amplifier current input is being used. Be sure all power is off before putting amplifier card on an extender.

Scaler/timer troubleshooting is easily performed since 10 of the 13 cards used (the 100 kc decade counter cards), are identical and may be interchanged at random. This allows troubleshooting by PC card substitution in the area of the 100 kc decade counter (see figure 4-5). The decade indicating lamps have an operating life tenure of approximately 1000 hours.

A TEST mode is included in the scaler

Figure 10-1. Card Locations

for checking purposes and can be a valuable aid in Spectrometer troubleshooting. In TEST the clock base for the Timer is inserted as the input to the scaler, allowing the scaler to be checked out with a steady signal applied.

Since the Analyzer has two modes of operation, MAN and AUTO, one means of troubleshooting here is by comparing results between the MAN and AUTO baseline modes (see paragraph 6.4, Section VI).

## 10.5 HIGH VOLTAGE POWER SUPPLY

For ease of maintenance and service, the HV power supply is mounted on two printed circuit cards (C22 and C27) which can be removed from the cabinet with minimum effort. A SAFETY INTERLOCK switch (S12) is provided, disabling the supply whenever the front panel is lowered exposing dangerous areas. Card C22 contains the circuits associated with the regulator. Card C27 houses the transformer, switches, and filter circuits. Either card may independently be removed while the power switch is on provided the INTERLOCK is operational and all high voltage has been removed from the circuit.

## 10.6 FUSE AND LAMP REPLACEMENT

### 10.6.1 Fuse Replacement

Table 6-2 sets forth the information relative to the fuse complement for the spectrometer. If it is determined that a fuse is suspect for instrument malfunction remove and replace as follows:

a. Press fuse cap in 90 degrees in the direction of the arrow. The fuse cap is spring loaded and will pop out after release.

b. Replace blown fuse in metal cap with one that is identical in size and rating.

c. Press cap back into its socket and turn fuse cap clockwise (cw) to lock into place

### 10.6.2 Decade Lamp Replacement

The more recent production models of the 530 Spectrometer are equipped with push-in type replaceable decade (SCALER-TIMER) lamps. These are not to be confused with the wired-in decade lamps on the older models. When ordering the push-in decade lamps, use Part No. 052064; and when ordering the wired-in type of decade lamp, use Part No. 030286.

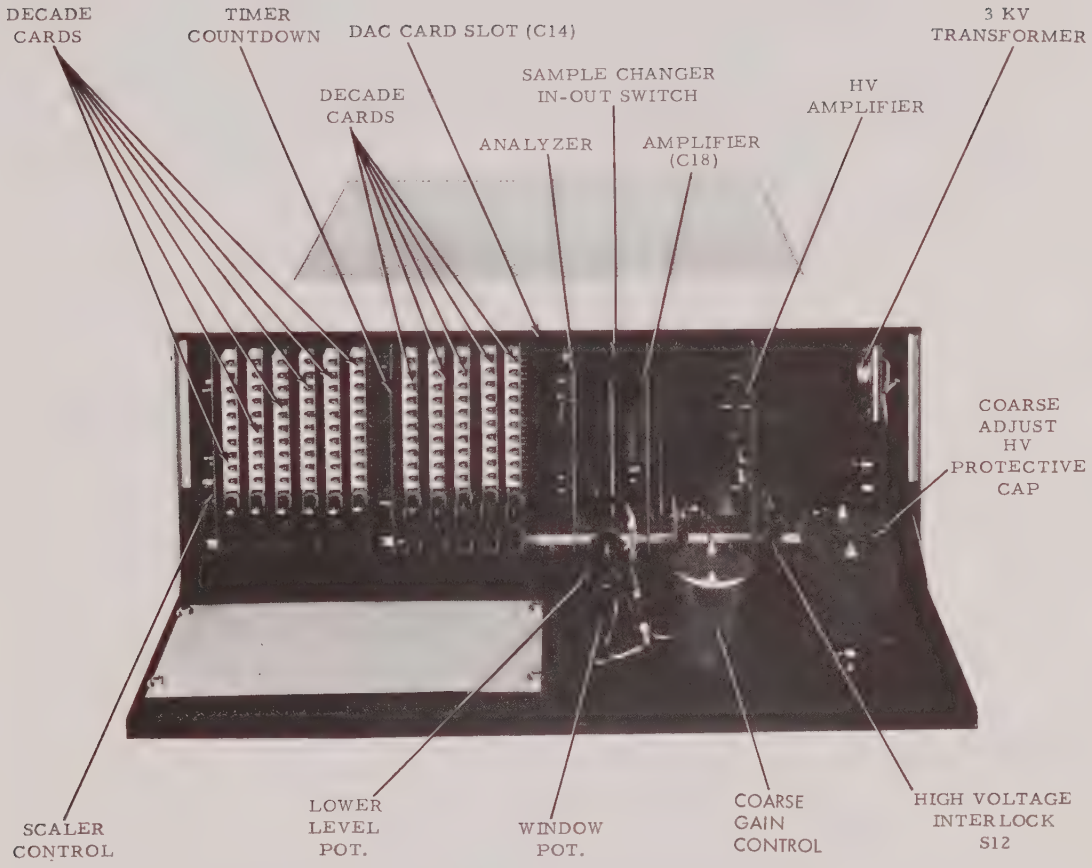


Figure 10-2. Spectrometer, Model 530 Showing PC Card Cage, Sample Selector Switch, and High Voltage Points

Table 10-1. Spectrometer Periodic Inspection Maintenance (sheet 1 of 2)

| Part or Assembly | Inspection | Frequency | Disposition |
|---|---|---|---|
| Instrument Housing | Inspect for dents, rust, scratches, fungus, or corrosion | Monthly or as required | Notify the responsible contractor Field Engineering personnel |
| Hinges and Latches | Inspect for binding or misalignment | Monthly or as required | Lubricate if necessary. Notify the responsible contractor Field Engineering personnel |

Table 10-1. Spectrometer Periodic Inspection Maintenance (sheet 2 or 2) (cont.)

| Part or Assembly | Inspection | Frequency | Disposition |
|---|---|---|---|
| Control Knobs, Switches and Potentiometers | Inspect for broken control knobs, switches and potentiometers. | Monthly or as required | Notify the responsible contractor Field Engineering personnel. |
| Air Ducts | Inspect for lint, carbon sludge, dirt or dust which would impair air circulation | Every two weeks | Clean air ducts. |
| Wiring | Inspect for broken or bent wiring or connections; inspect for frayed or burnt insulation | Monthly or as required | Notify the responsible contractor Field Engineering personnel |
| Capacitors and Resistors | Inspect for bulging containers, melted wax or other leakage; also for chars or burns indicating exposure to high temperature | Monthly or as required | |
| Transformers | Inspect for leakage, indications of over-heating, visible charred or burned insulation or finish | Monthly or as required | |
| Printed Circuit Cards | Inspect for damaged cards and improper card seating | Monthly or as required | Replace |
| Fuses | Inspect for burnout. | As required | Replace if broken or burned out |
| Indicating Lamps. PC Card Incandescent Decade Lamps. | Inspect for burned out or broken lamps | As required | Replace indicating lamp. Replace PC decade card |
| Line Power Card | Inspect for kinks, strains, breaks, frayed insulation and cuts. | Monthly or as required | Repair or replace |

## 10.7 PARTS LIST

### 10.7.1 Introduction

All Model 530 Spectrometer components are fully indentified in order to make possible procurement of replacements. Reference designations in the series from 1 through 99 appear schematically on the Spectrometer Logic Diagram, figure 4-1; reference designations in the series from 100 through 199 and 200 through 299 appear schematically on Baird-Atomic drawings 30238 and 30240 respectively which are included with this manual. The reference designations identify

electrical/electronic component parts referenced in drawings or the text of this manual; mechanical parts which are not likely to require replacement during normal Spectrometer service life are not assigned reference designations or included in this parts list.

For easy location all items given a reference designation in the parts list are arranged in alphanumerical order. Exact Spectrometer panel stamping, when it exists, is reproduced as part of the name of component and description column. Those few items listed without an assigned reference designation are included last in alphabetical order.

10.7.2 Model 530 Spectrometer Parts List

| REF. DESIG. | NAME OF COMPONENT AND DESCRIPTION | PART NUMBER |
|---|---|---|
| C1 | Capacitor, 10 mf, 25 volts | 20938 |
| C2 and C3 | Capacitor, 0.001 mf, 10 kv | 00476 |
| C102 and C103 | Capacitor, 0.22 mf, 25 volts | 30318 |
| C1 | Scaler control board | 30277 |
| C2 | 100 kc decade board | 30306 |
| C3 | 100 kc decade board | 30306 |
| C4 | 100 kc decade board | 30306 |
| C5 | 100 kc decade board | 30306 |
| C6 | 100 kc decade board | 30306 |
| C7 | 1 mc decade board | 30202 |
| C8 | Timer Countdown board | 30188 |
| C9 | 100 kc decade board | 30306 |
| C10 | 100 kc decade board | 30306 |
| C11 | 100 kc decade board | 30306 |
| C12 | 100 kc decade board | 30306 |
| C13 | 100 kc decade board | 30306 |
| C15 | Analyzer board | 30283 |
| C18 | Amplifier board | 31604 |
| C22 | HV amplifier board | 30288 |
| C27 | 3 kv transformer board | 32176 |

PARTS LIST (cont.)

| REF. DESIG. | NAME OF COMPONENT AND DESCRIPTION | PART NUMBER |
|---|---|---|
| F101 and F102 | Fuse, 1.5 amp, SLO-BLO | 08627 |
| I1 | 1.5 KV, indicator lamp | 00922 |
| I2 | 3 KV, indicator lamp | 00922 |
| J1 | PRINTER, 50-pin connector | 21216 |
| J2 | 1.5 KV OUT, MHV connector | 00698 |
| J3 | CURRENT INPUT, MHV connector | 00698 |
| J4 | PRE-AMP, 7-pin connector | 00742 |
| J5 | VOLTAGE INPUT, BNC connector | 00756 |
| J6 | ANALYZER OUTPUT, BNC connector | 00756 |
| J7 | 3 KV OUT, MHV connector (UG931/U) | 00698 |
| P1 | FINE GAIN, potentiometer, 6 k, 2 watt, ± 5 percent | 32213 |
| P2 | LOWER LEVEL, potentiometer, 1 k, 2 watt, 10-turn | 30390 |
| P3 | WINDOW, potentiometer, 1 k, 2 watt, 10-turn | 30390 |
| PB1 | START, pushbutton switch (black) | 01255 |
| PB2 | STOP, pushbutton switch (red) | 03124 |
| PB3 | CHANNEL RESET, pushbutton switch | 02155 |
| R1 | Resistor, 4.02 k, 1/4 watt, ±1 % | 32212 |
| R2 | Resistor, 36 k, 1/3 watt, ±1 % | 32210 |
| R3 | Resistor, 500 k, 4 watt, ±1 % | 32211 |
| R4 | Resistor, 5 ohms, 10 watt, ± 5 % | 04226 |
| R5 | Resistor, 220 k, 2 watt, ± 5 % | 01093 |
| R6 | Resistor, 100 k, 1/2 watt, ± 1 % | 01148 |
| R7 | Resistor, 20 m, 2 watt, ± 1 % | 08054 |
| R101 and R105 | Resistor, 90.9 ohms, 1/4 watt, ± 1 % | 30265 |
| R102 and R106 | Resistor, 191 ohms, 1/4 watt, ± 1 % | 30266 |
| R103 and R107 | Resistor, 412 ohms, 1/4 watt, ± 1 % | 30267 |
| R104 | Resistor, 953 ohms, 1/4 watt, ±1 % | 30269 |
| R108 | Resistor, 43 k, 1/2 watt, ±5 % | 30371 |
| R109 | Resistor, 36 k, 1/2 watt, ±5 % | 00343 |
| R110 | Resistor, 24 k, 1/2 watt, ±5 % | 00350 |

PARTS LIST (cont.)

| REF. DESIG. | NAME OF COMPONENT AND DESCRIPTION | PART NUMBER |
|---|---|---|
| R111 | Resistor, 13 k, 1/2 watt, ± 5 % | 00364 |
| R201 and R202 | Resistor, 500 k, 4 watt, ± 1 % | 32211 |
| R203, R204 R205, R206 | Resistor, 100 k, 1/3 watt, ± 1 % | 30346 |
| R207 | Resistor, 50 k, 1/4 watt, ± 1 % | 30345 |
| R208, R209 R210, R211 | Resistor, 10 k, 1/4 watt, ± 1 % | 30344 |
| S1 | PSC-BS, slide switch, SPDT | 30367 |
| S2 | 0.1 SEC-0.1 MIN, slide switch SPDT | 30367 |
| S3 | MAN-AUTO-TEST, slide switch, SPTT | 30366 |
| S4 | ON-POWER-OFF, toggle switch, SPST | 30341 |
| S5 | INT- DIFF, slide switch, SPDT | 30367 |
| S6 | MAN-AUTO, slide switch, 4PDT | 30368 |
| S7 | ON-STANDBY, slide switch, SPDT | 30367 |
| S8 | COARSE GAIN, rotary switch, 4-pole, 2-6 position | 30376 |
| S9 | COARSE ADJUST, rotary switch, 3-pole, 10 position | 32216 |
| S10 | FINE ADJUST, rotary switch, 2-pole 2-12 position | 32217 |
| S11 | SAMPLE CHANGER IN-OUT, slide switch, DPDT | 30472 |
| S12 | Interlock switch (behind front panel; turns HV on) | 30320 |
| S15 | HV RANGE, rotary switch, 5-pole, 2 position | 32215 |
| | Cabinet (including stand) | 31471 |
| | Connector, 23-pin | 30289 |
| | Instruction manual | 31426 |
| | Knob, 10-turn | 43437 |
| | Knob, round skirted | 42003 |
| | System supply, LV | 30571 |

10.8 Digital-To-Analog Converter PARTS LIST

| REF DESIG. | NAME OF COMPONENT AND DESCRIPTION | PART NUMBER |
|---|---|---|
| *C14 | Triple decade buffer and DAC board | 32399 |
| R2 | SPAN ADJ, potentiometer, 2 k, 2 watt, 10 % | 01087 |
| S13 | DAC RANGE, rotary switch, 12-pole, 4 position | 32400 |
| S14 | 100 MV-1 MA, recorder slide switch, DPDT | 30472 |
| | RECORDER, terminal strip, 6-terminal | 01359 |

*Model 530 printed circuit board location

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# APPENDIX

## Model 530 Spectrometer Schematic Drawings

| DWG. NO. | NAME |
|---|---|
| C-30086 | System Supply |
| D-30179 | 1 mc Decade Counter |
| D-30180 | 100 kc Decade Counter |
| D-30181 | Timer Count Down |
| D-30184 | Amplifier |
| D-30203 | Scaler Control |
| D-30204 | Analyzer |
| B-30238 | HV Supply Coarse & Fine Adjust |
| B-30240 | Amplifier Coarse Gain Switch |
| D-30241 | HV Amplifier |
| E-30326 | Model 530 Spectrometer Logic Diagram |
| D-32173 | 3 KV Transformer |

## Digital-to-Analog Converter Schematic Drawings

| DWG. NO. | NAME |
|---|---|
| D-31620 | Model 530 Switching for Triple Decade Buffer and DAC Logic Diagram |
| D-32380 | Triple Decade Buffer and DAC |

BAIRD-ATOMIC

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